

Animal health economics for DVM

Course Code: Vetm-5231

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1. Introduction to principles of economics

1.1. Definition, Branches and Role of economics

What is economics?

What is economics?

- **Economics** is “...a social science that deals with how consumers, producers and societies choose among the alternative uses of scarce resources in the process of producing, exchanging, and consuming goods and services”.
- It is social because it involves people and their behavior.
- It is a science because it uses, as much as possible, a scientific approach in its investigation of choices.

Types of Economics

The field of economics is typically divided into two broad categories: microeconomics and macroeconomics.

- **Micro** - focuses on the choices made by individual decision-making units in the economy—typically consumers and firms—and the impacts those choices have on individual markets.
- **Macro** - focuses on the impact of choices on the total, or aggregate, level of economic activity.
- Alternative economic systems
 - For example: Capitalism and socialism
 - Most countries have mixed economic systems

- **Behavioural Economics:** It studies the effects of social, psychological, cognitive, and emotional factors on the economic decisions. It uses mainly microeconomics.
- **Ecological Economics:** It studies the relation between the economy and the environment and how to achieve sustainable development.
- **Environmental Economics:** How natural resources are developed and managed. It uses mainly microeconomics.
- **Health Economics:** It studies the economy of the health and health care sector. Focused on microeconomics.
- **Information Economics:** How information and information systems affect an economy and economic decisions. It uses mainly microeconomics.
- **International Economics:** How economic relations between countries, mainly trade, investment and labor flows, affect the economies. It can use microeconomics models, but is focused on macroeconomics aggregates.
- **Labour Economics:** It studies the labour (job) markets. It also uses a lot of tools from the microeconomics, but it can include macroeconomic analysis.
- **Monetary Economics:** It studies means of payments (money, etc.) markets.
- **Population Economics:** It studies demography using the tools of economics, and the relation between economy and population.
- **Public Finance:** It studies the role of the government in the economy: public spending, taxes, deficit, etc.
- **Urban Economics:** It applies the tools of economics to the study of cities: transit, housing, crime, etc.

Animal health economics

Animal health economics is “...a social science that deals with how consumers, producers and societies (can) choose among the alternative uses of scarce resources in the process of producing, exchanging, and consuming animal products, with special reference to animal health aspects”.

Animal health economics has two interrelated branches:

1. economics for the planning and management of animal health services, and
2. economic analysis of diseases and interventions.

It applies the principles and methods of economic analysis as an **aid to decision making on animal health interventions** at various levels.

Key changes affecting decisions on animal health measures:

- (1) Major evident epidemic diseases are under control in the majority of the developed countries leaving diseases with less evident economic impact and more complex epidemiology to be tackled by the veterinary profession;
- (2) Self-sufficiency for livestock products receives lower priority as national policy goal and hence political commitment for national disease control efforts has weakened;
- (3) the importance of agriculture in the national economy declines as countries develop, resulting in stronger competition for funds by different sectors of the economy, and;
- (4) more and more responsibilities are being transferred from the public to the private sector, which is more concerned with visible returns on investment.

As a result of these developments, it has become increasingly **important to provide sound economic justification** for any proposed action to improve animal health to those expected to finance the proposed intervention.

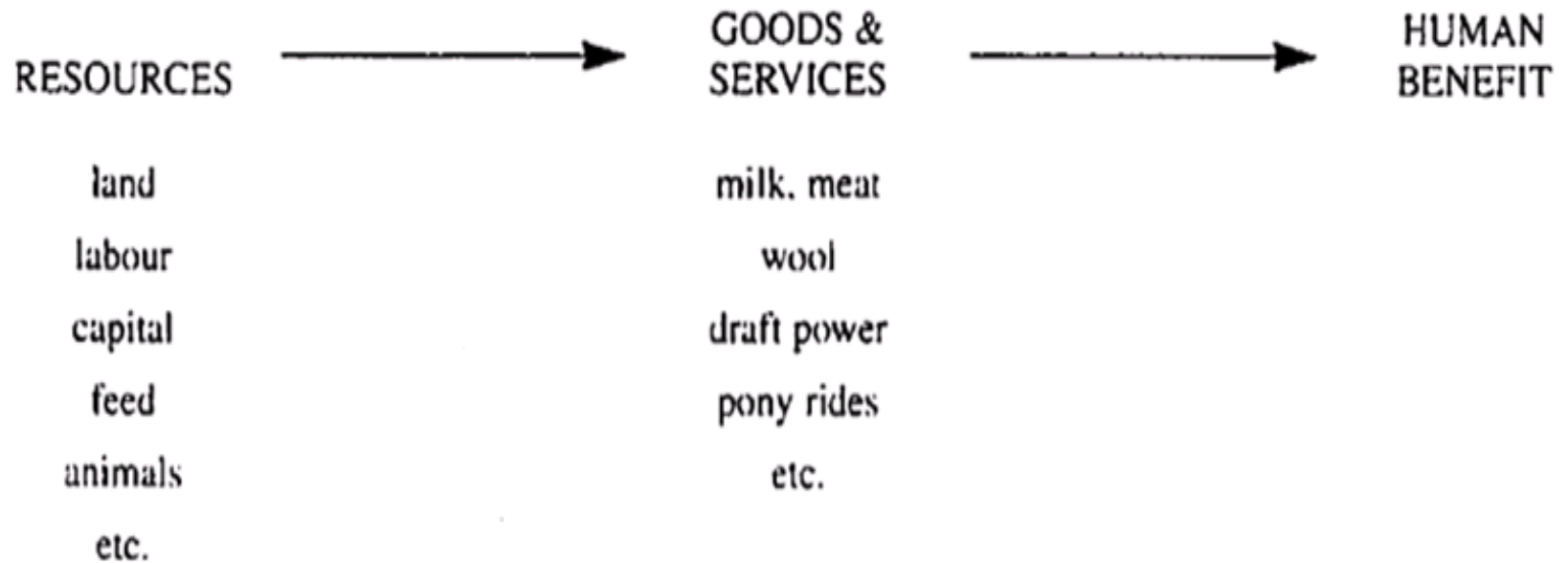
Examples:

- Action on disease **control is economically justified only if the estimated benefits at least cover the costs incurred**, i.e. the benefit/cost ratio must be greater than or equal to one.
- If two or more programs are available for controlling a disease, the one with the **highest benefit/cost ratio** is generally chosen.

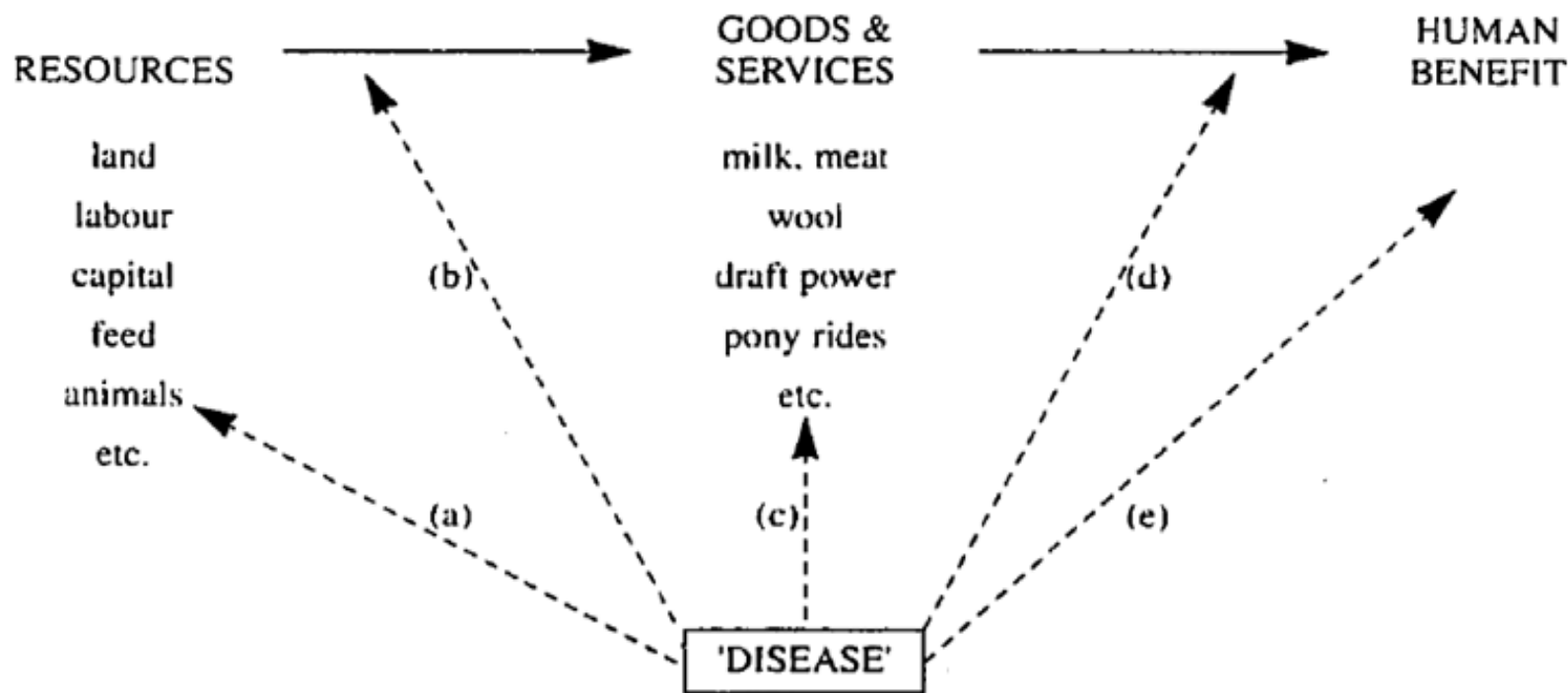
- Cow with disease: (what) treatment, no treatment, culling?
- Herd problem:
 - production diseases: preventive measures
 - endemic diseases: eradication?
- Regional problem: eradication, stimulation of voluntary disease control?

Economic nature of animal health

Livestock resource transformation process

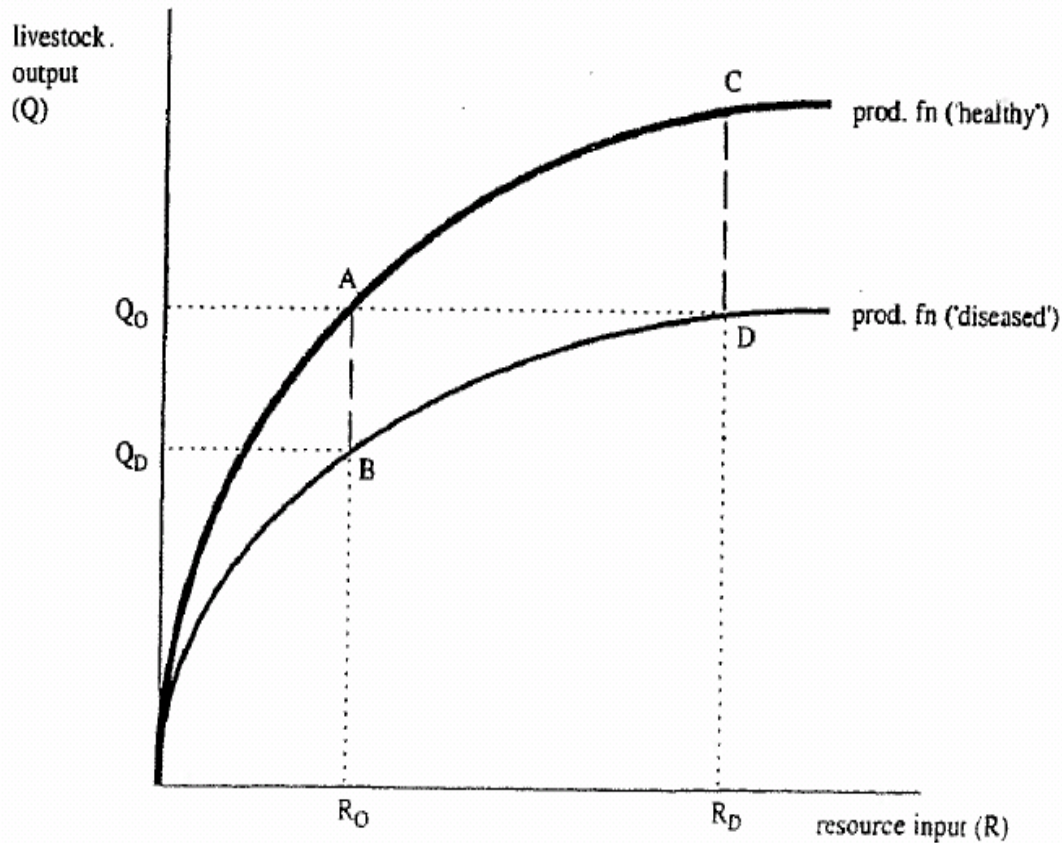


- (a) destroys the basic resources (mortality of breeding or productive animals)
- (b) lowers the efficiency of the production process and the productivity of resources used (reduced rates of growth or feed conversion)
- (c) reduces the realised physical output of the production process or its unit value (lowered milk yield or quality).



- (d) lower the suitability of livestock products for processing, or generate additional costs in the distribution chain (drug residues, meat inspection)
- (e) affect human well-being directly (zoonoses such as salmonella and brucellosis).

Figure 3 Disease Effects on the Livestock Production Function



Disease effects:

- I. Efficiency of production
 - Cost of production
 - Changes in supply

- II. Changes in demand
 - ✓ Quality of the product
 - ✓ Prices
 - ✓ Image

Other effects

- Effect on cultural value of animal. Some disease make the animals unfit for cultural functions
- Effects on welfare

1.2. Concept of limited resources and unlimited wants

Economics is the study of choice.

- All choices mean that **one alternative is selected over another**. Selecting among alternatives involves three ideas central to economics:
 1. Scarcity
 2. Choice, and
 3. Opportunity cost.

Economists study choices that scarcity requires us to make.

What is Scarcity?

Scarcity

- Our resources are limited/scarce.
- A scarce good is one for which the choice of one alternative requires that another be given up. The test of whether a resource is scarce is whether it has alternative uses.
- At any one time, we have only so much land, so many factories, so much oil, so many people. But **our wants, our desires for the things that we can produce with those resources, are unlimited.** We would always like more and better housing, more and better education - more and better of practically everything.
- If our resources were unlimited, we could say yes to each of our wants - and there would be no economics. To say yes to one thing requires that we say no to another. Whether we like it or not, we must make choices.
- Our **unlimited wants** are continually colliding with the **limits of our resources**, forcing us to pick some activities and to reject others.

Choice

- Resource scarcity - natural, human and manufactured – forces individuals and societies to make choices.
- Economists assume that individuals **make choices that they expect will create the maximum value of some objective, given the constraints they face.**

Example: consider a parcel of land. The parcel presents us with several alternative uses. Such as:

- We could build a house on it.
- We could put a gas station on it.
- We could create a small park on it.
- We could leave the land undeveloped in order to be able to make a decision later as to how it should be used.

- The existence of alternative uses forces us to make choices.
 - Suppose we have decided the land should be **used for housing**. Should it be a large and expensive house or several modest ones?
 - Suppose it is to be a large and expensive house. Who should live in the house?
- There are alternative uses of the land both in the sense of **the type of use** and also in the sense of **who gets to use it**.
- **The fact that land is scarce means that society must make choices concerning its use.**

The choices we confront as a result of scarcity raise three fundamental economic questions.

- **What goods and services should be produced, and in what quantities?** Using scarce resources to produce one thing requires giving up another.
- **How to produce goods and services?**
- Should a firm employ a few skilled or a lot of unskilled workers?
Should it produce in its own country or should it use foreign plants?
- **For whom to produce goods and services?** Consumers have varying income, tastes, traditions, age, etc. Economics should not only determine the target market for goods, but also take into account how much income they have.

What is opportunity cost?

Opportunity cost

- Opportunity cost is the value of the best alternative forgone in making any choice.
- The opportunity cost of any action is the highest-valued alternative forgone or you give up to get it.
- When an action is chosen, the highest-valued alternative NOT chosen is called the opportunity cost.

Ex.

- The opportunity cost to you of reading the remainder of this course will be the value of the best other use to which you could have put your time.
- During the next hour Kebede can play basketball, watch television, or read a book. The opportunity cost of reading a book is the value of playing basketball if Kebede prefers that to watching television.
- When the government chooses to use resources to build a dam, these sources are no longer available to build a highway. This choice illustrates the concept of opportunity cost.

- If doing one thing requires giving up another, then the expected benefits of the alternatives we face will affect the ones we choose.
- Every choice has an **opportunity cost** which affect the choices people make. Therefore, understanding of opportunity cost is crucial to the examination of choices.
- *Summary: A good is scarce if the choice of one alternative requires that another be given up. The existence of alternative uses forces us to make choices. The opportunity cost of any choice is the value of the best alternative forgone in making it.*

1.3. Factors of production

Land: Includes land forms associated with the earth's crust and resources such as minerals, forests, ground water, etc. Resources classified as either renewable (e.g. forests) or non renewable (e.g. minerals).

Labour: all owner and hired labor services used in production, excluding management

Capital: in the context of production it refers to manufactured goods such as fuel, chemicals, tractors and buildings. Capital goods don't provide consumer satisfaction directly.

Management: production decisions designed to achieve specific economic goal

Questions

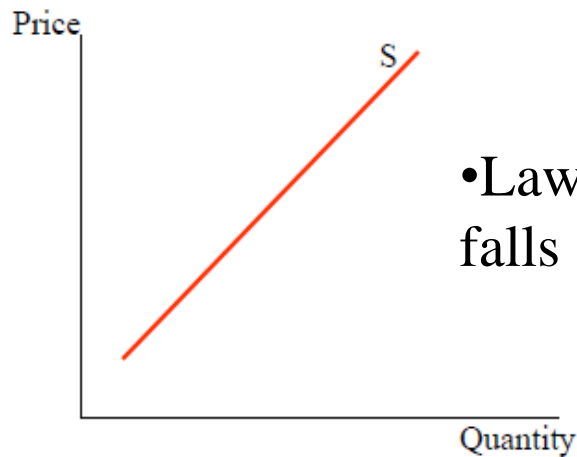
3. Market behavior

3.1. Supply and demand and market equilibrium

Supply

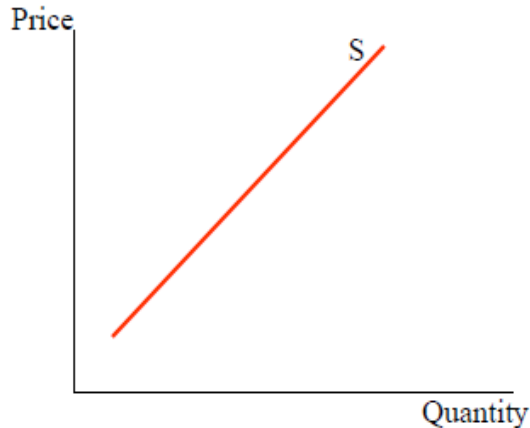
- Supply – the amount of a good that a firm is willing and able to offer for sale at different market prices, holding all else

The supply curve



- Law of Supply – as price falls the quantity supplied falls and vice versa, holding all else constant.

The supply curve



Determinants of Supply

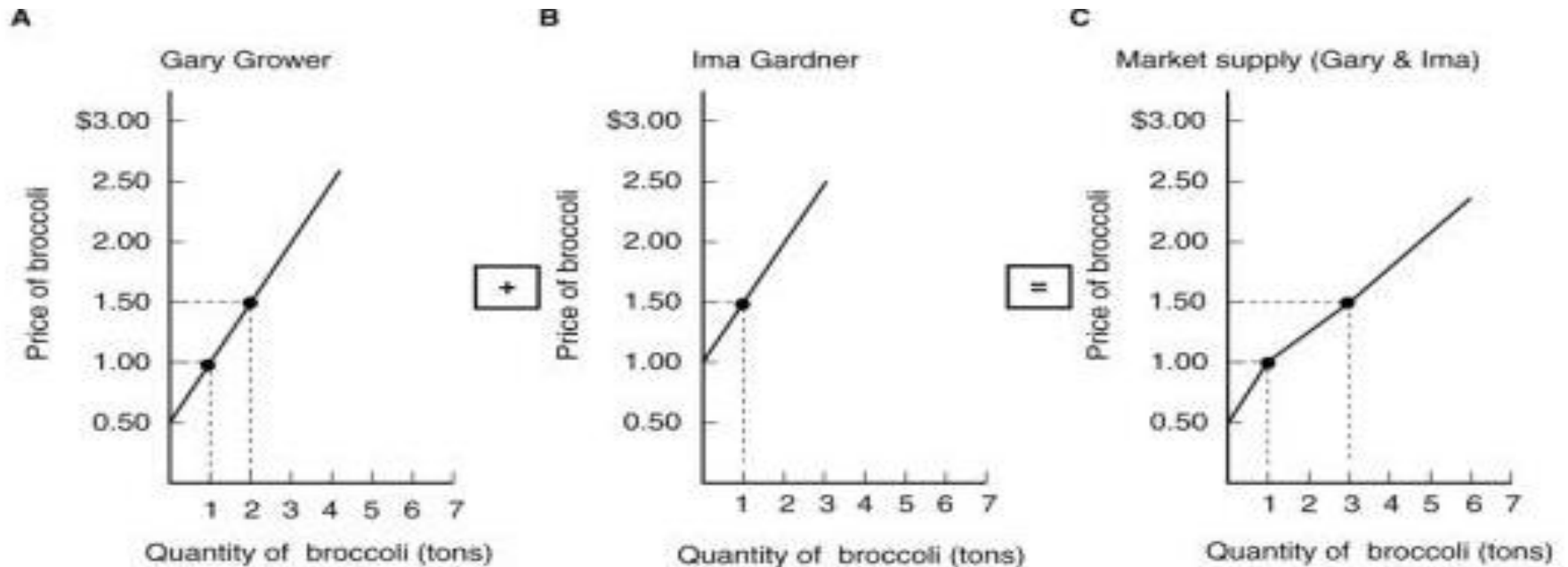
1. Cost of Production
 - a. Prices of required inputs
 - b. Technologies used in production
2. Price of Related Products

New technology

- produce output for less input
- higher profit on output
- produce more at current P
- increase in supply

- Market supply curve is horizontal summation of the supply decisions of all firms in the market.

Example: At a price of €1.50, 2 tons of broccoli by Gary + 1 ton by Ima giving a market supply of 3 tons of broccoli.



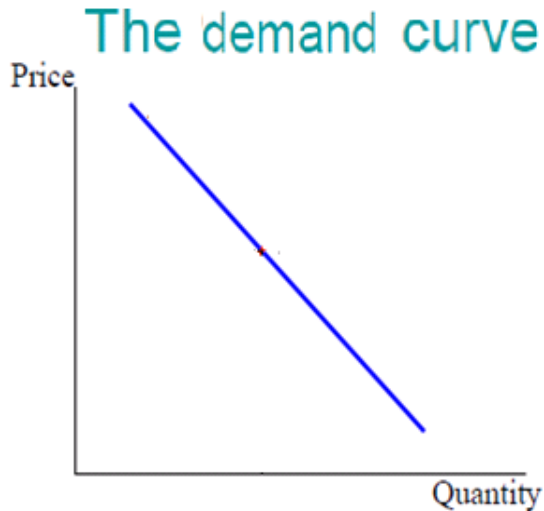
Demand

- Demand – the amount of a good that a consumer is willing and able to purchase at different market prices, holding all else constant.



Demand Curve shows how much a consumer is willing to purchase at different market prices.

Downward sloping suggest that consumers demand more at lower price.

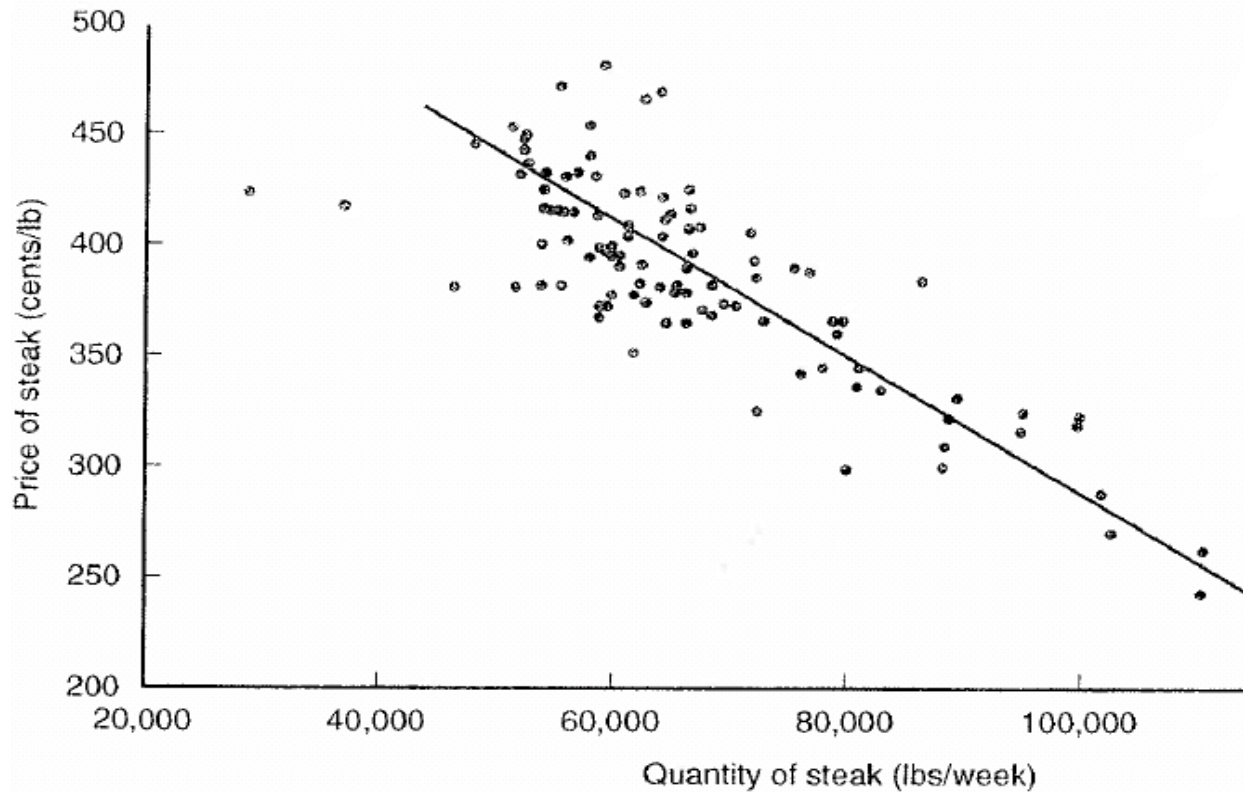


Determinants of Demand

1. Income
2. Price of Related Goods
 - a. Substitute Goods
 - b. Complementary Goods
3. Tastes and Preferences
4. Expectations

- Normal Good – the higher the income the more the consumption
- Inferior Good – as income rises consumption less
- Tastes / Preference, New tastes for the product, consume more, $\uparrow D$
- Expectations, \uparrow Price tomorrow buy today instead of tomorrow, $\uparrow D$

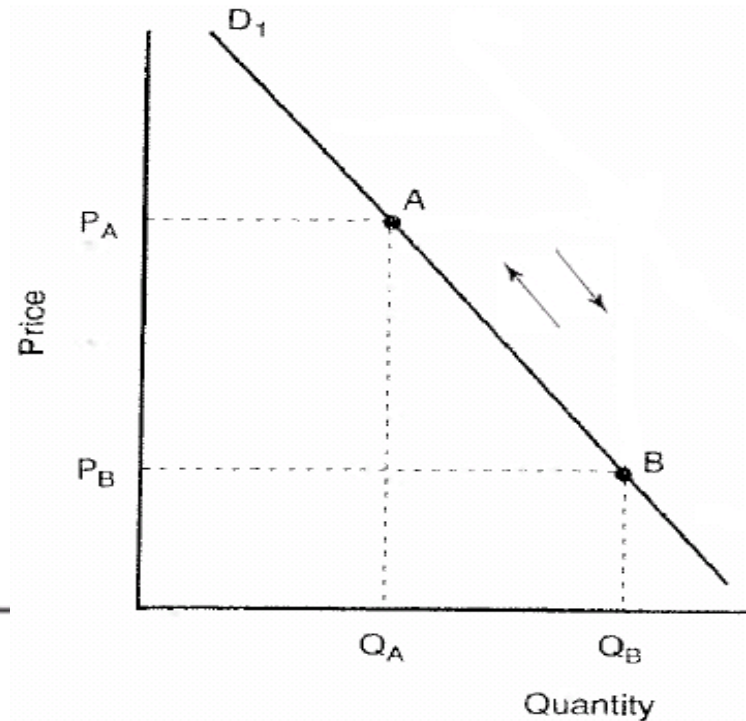
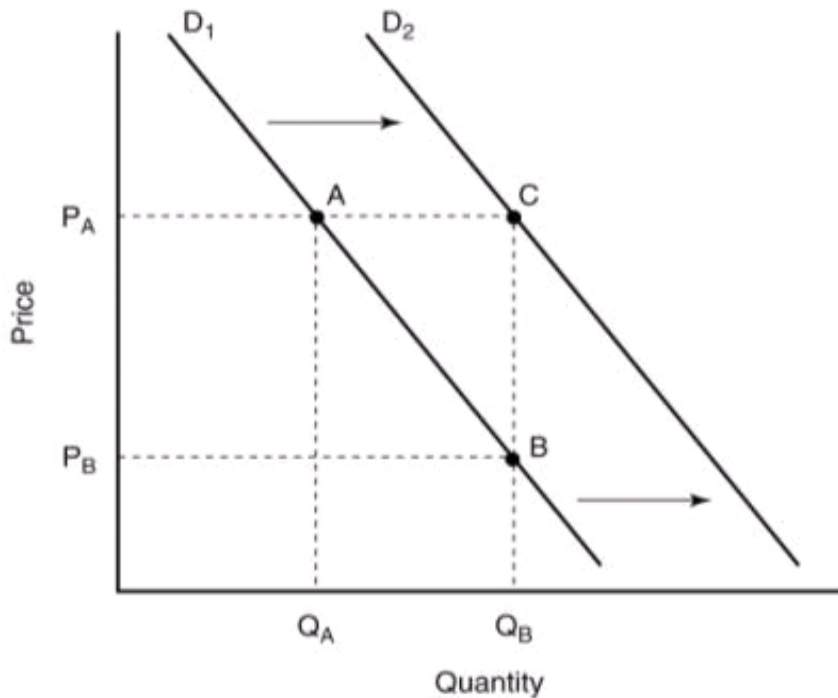
- Consumer response to a decline in product price is by purchasing more of the product. This inverse relationship between price and quantity demanded is the **law of demand**.



Scatter plot analysis of demand for steak.

Terms to discuss events in the market place:

- *Change in demand* is a shift in the demand curve.
- *Change in the quantity demanded* is a movement along a demand curve.

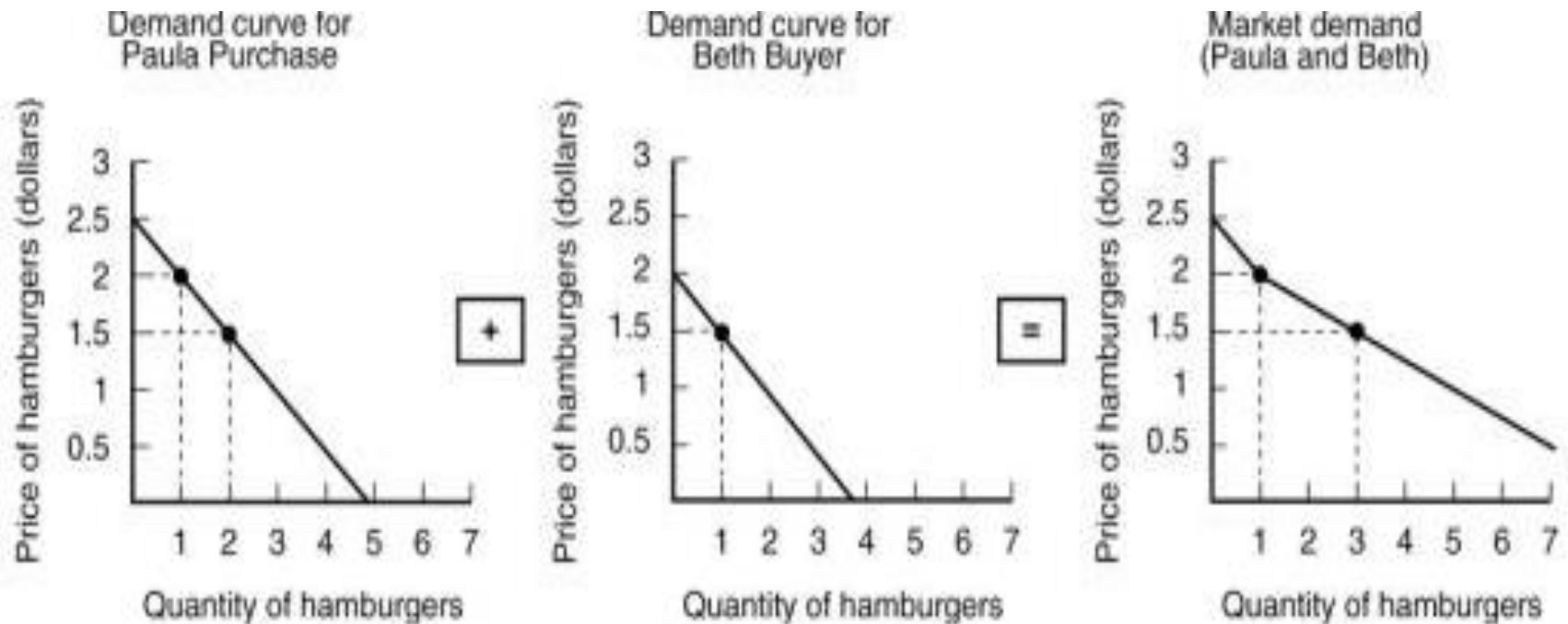


Change in **demand** is due to:

- Change in product of **substitute**, or
- Change in product of **complements**, or
- **change in income**.

Change in quantity demanded is due to **increase or decrease in product price**.

Market demand for any consumer good is the horizontal summation of the quantities demanded by all individual consumers at a particular price in the market.



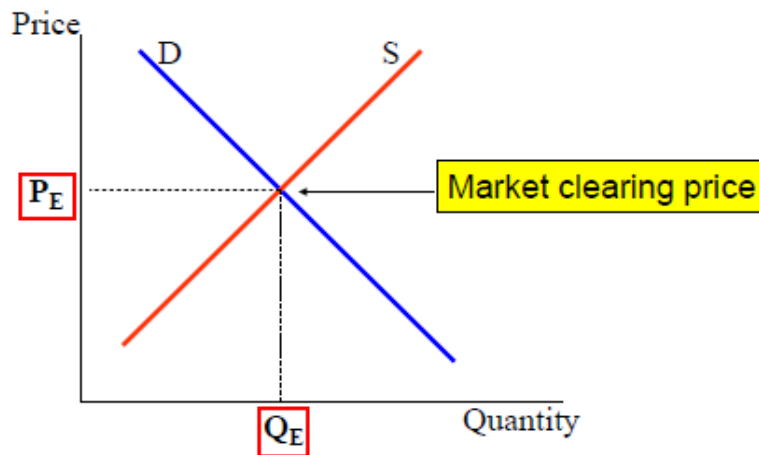
Example: At a price of €1.50, 2 hamburgers demanded by Paula + 1 hamburger demanded by Beth giving market demand of 3 hamburgers.

At price € 2.00: Demand: $1 + 0 = 1$

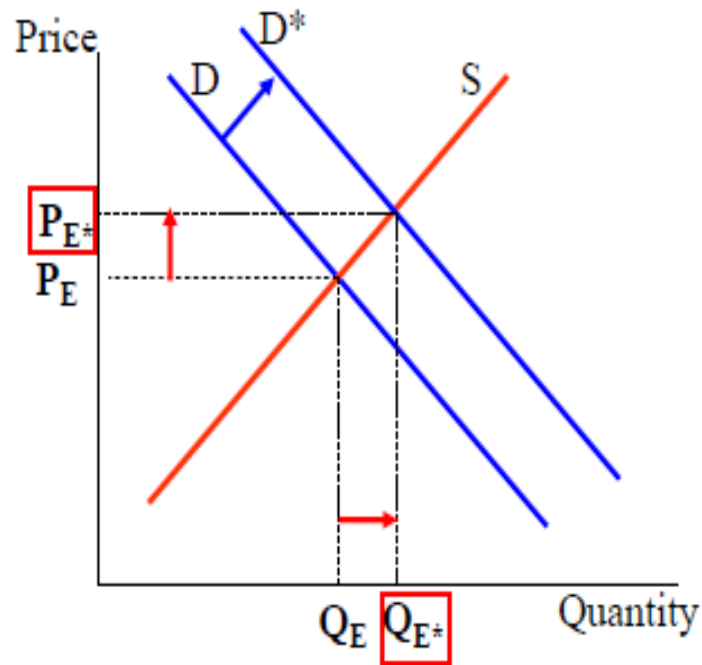
Market equilibrium

- Market Equilibrium – occurs when there is no incentive for prices to change (a steady state). This occurs when there is no surplus or shortage, quantity demanded equals the quantity supplied, $Q_S = Q_D$. At this point, equilibrium price and equilibrium quantity can be established.

Merging demand and supply



It is where the supply and demand curves cross.



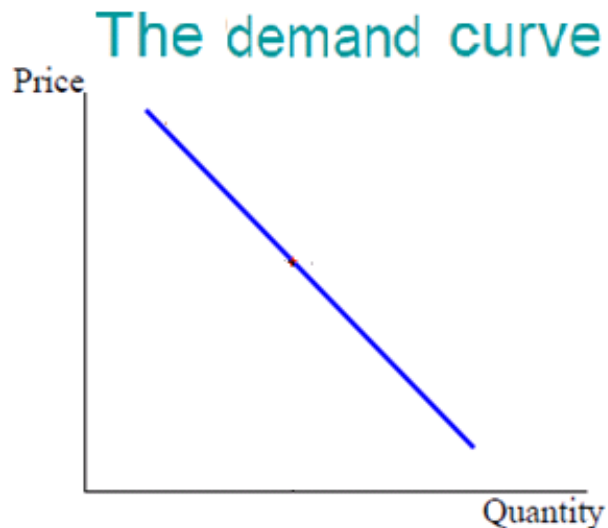
When demand increases and supply remains the same, the higher demand leads to a higher equilibrium price and vice versa.

2.2. Price and income elasticity of demand and supply

Elasticity is the degree of consumer responsiveness to change in price and incomes.

Own price elasticity of demand

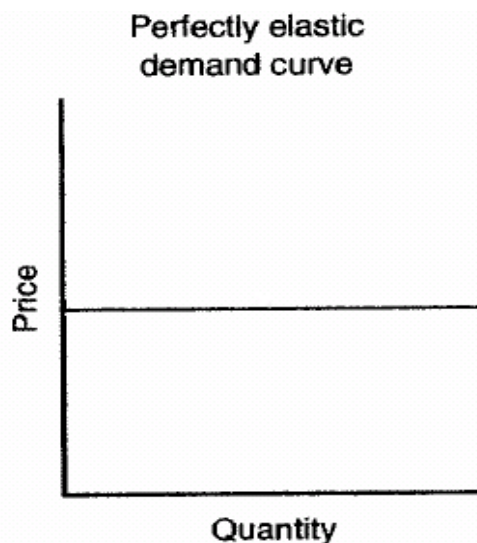
It compares the difference between the change in quantity demanded with the change in the price of a good in percentage terms. It measures the sensitivity to changes in price of a particular product.



$$\text{Own price elasticity of demand} = \frac{\% \Delta Q}{\% \Delta P}$$

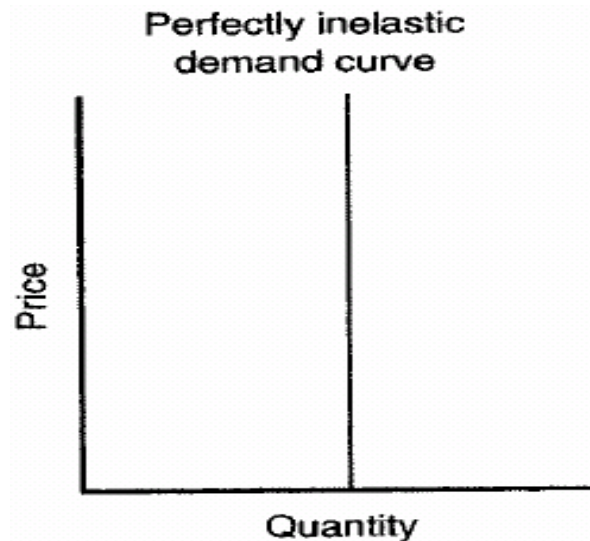
Because demand curve slope downward, the measure of own price elasticity is always negative.

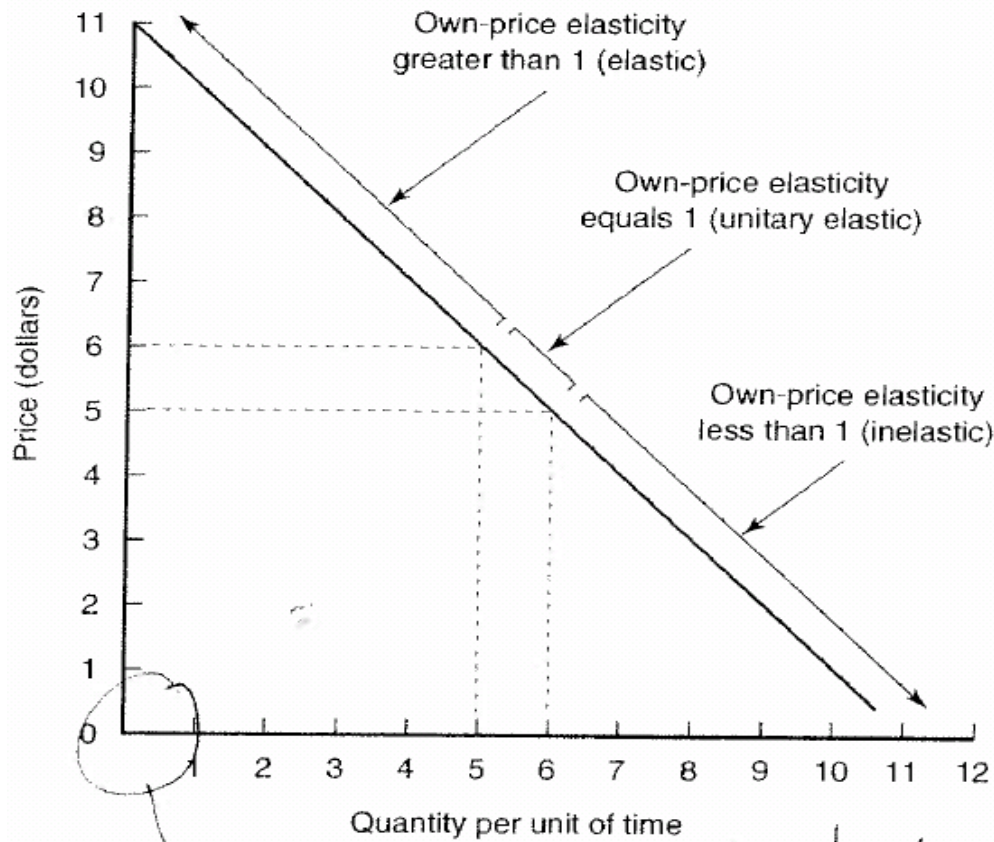
- When the price elasticity of demand for a good exceeds one (in absolute value), the percentage change in quantity is greater than the percentage change in price. We call the response **elastic demand**.
- If price elasticity is equal to 1, percentage change in quantity is equal to percentage change in price. It is called **unitary elastic demand**. There would be no change in consumer expenditures when price changes.
- If demand curves flat, or horizontal, it is **perfectly elastic demand**.



If price elasticity of demand for a good is less than one (in absolute value), demand is **inelastic**. That is the percentage change in the quantity demanded is less than the percentage change in the product price. Thus consumer expenditures fall when price falls.

If the curve is perpendicular to horizontal, or vertical, it is **perfectly inelastic demand**.





If the Own-Price Elasticity Is:	Demand Is Said to Be:	Percentage Change in Quantity Is:
Greater than one	Elastic	Greater than percentage change in price
Equal to one	Unitary elastic	Same as percentage change in price
Less than one	Inelastic	Less than percentage change in price

Example: Consumption of hamburgers drops from three hamburgers to two hamburgers when the price increases from 1 to 1.25 Dollars per hamburger. The average quantity over this range would be equal to 2.5 (i.e., $(2+3)/2$), while the average price would be 1.125 (i.e., $(1.25+1)/2$). What is the own price elasticity of demand?

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$$\begin{aligned} \text{own-price} \\ \text{elasticity} \\ \text{of demand} &= \frac{(Q_A - Q_B) \div ([Q_A + Q_B] \div 2)}{(P_A - P_B) \div ([P_A + P_B] \div 2)} = \\ &= \frac{(2 - 3) \div 2.5}{(\$1.25 - \$1.00) \div \$1.125} = -1.8 \end{aligned}$$

Q_A and Q_B represent the quantity and price after the change, and Q_B and P_B represent quantity and price before the change. Thus, a 1% fall (rise) in the price of a hamburger will increase (reduce) quantity demanded by 1.8%.

Income elasticity of demand

It is the effects of changes in income on changes in quantity demanded in percentage. It measures the sensitivity to changes in income.

It is a measure of the responsiveness of the quantity of a good purchased due to changes in income, all other factors constant.

$$\text{Own price elasticity of income} = \frac{\% \Delta Q}{\% \Delta I}$$

If the Income Elasticity Is:

Greater than one

Less than one but greater than zero

Less than zero

The Good Is Classified As:

A luxury and a normal good

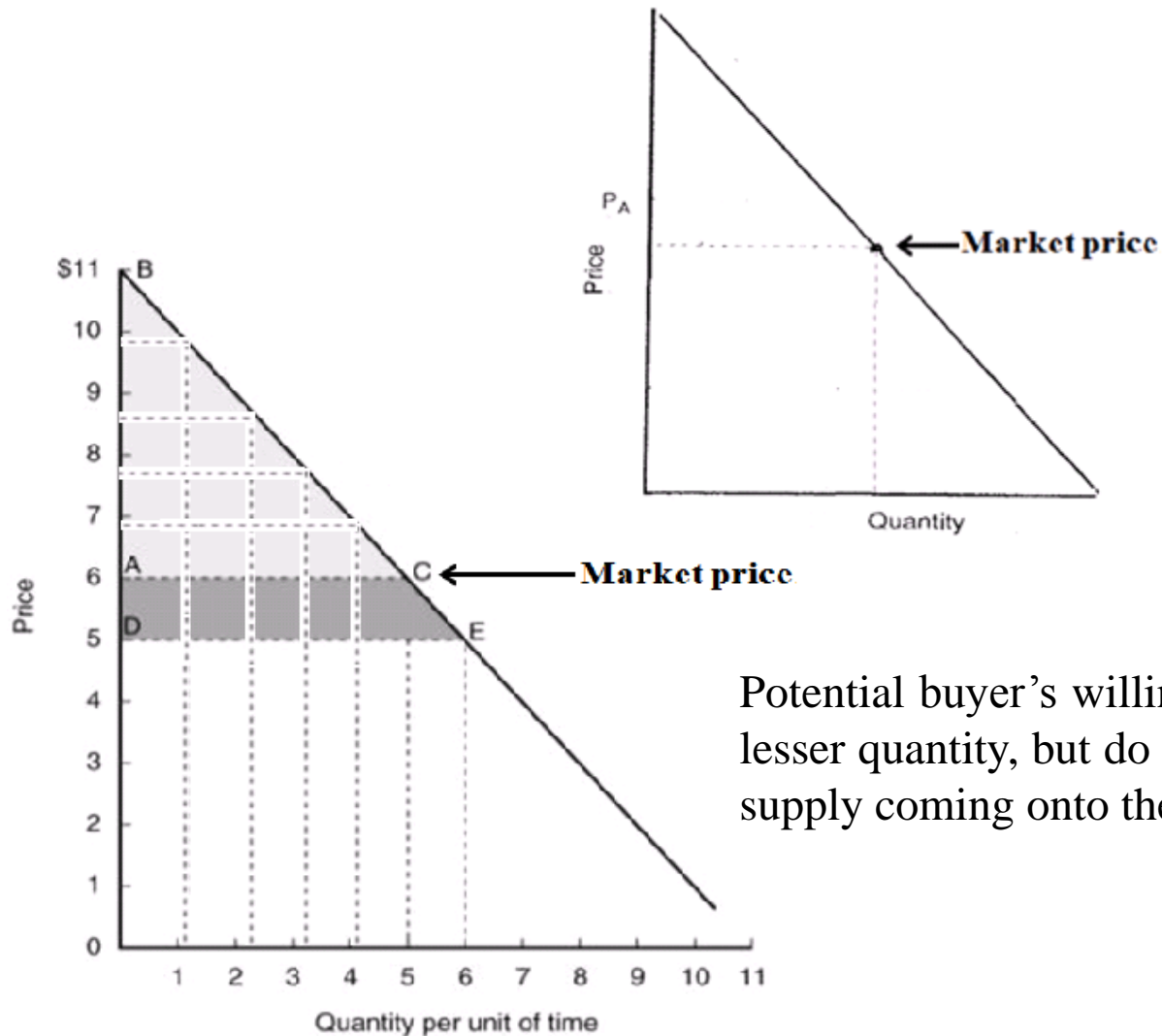
A necessity and a normal good

An inferior good

Questions

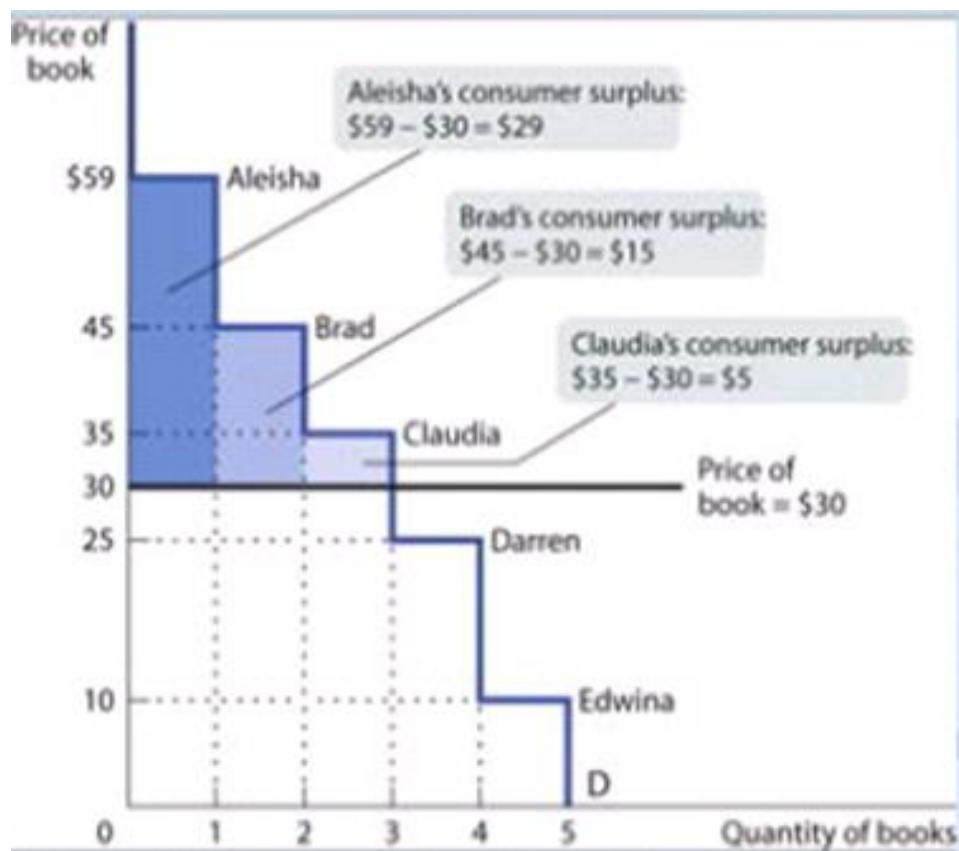
2.3. Consumer surplus and producer surplus

Consumer surplus



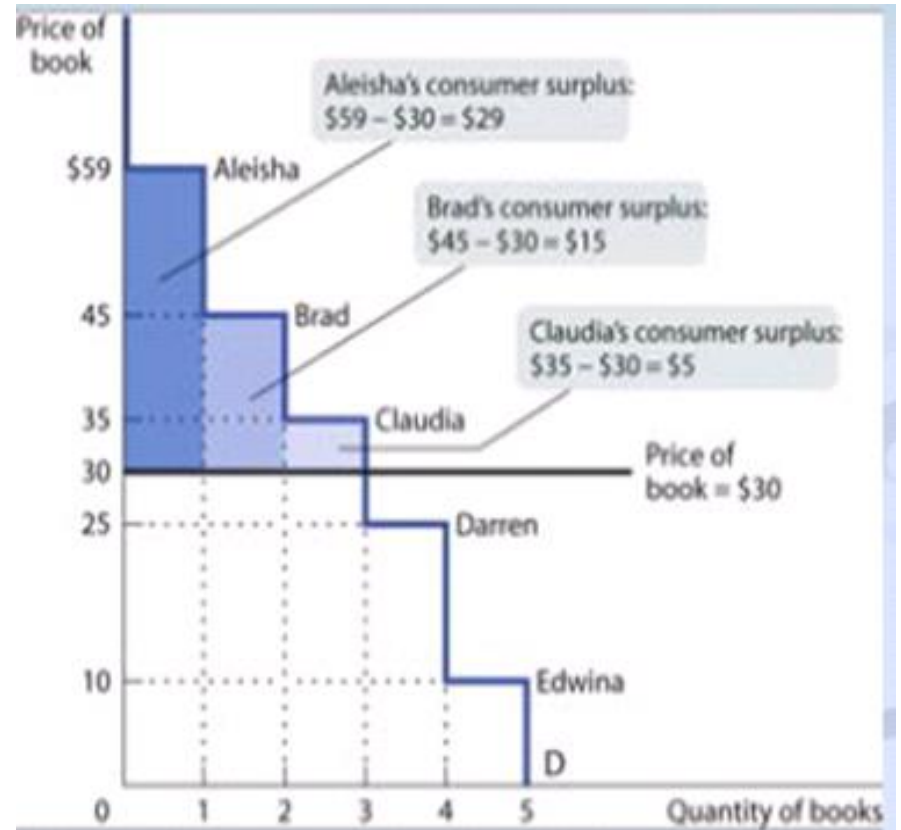
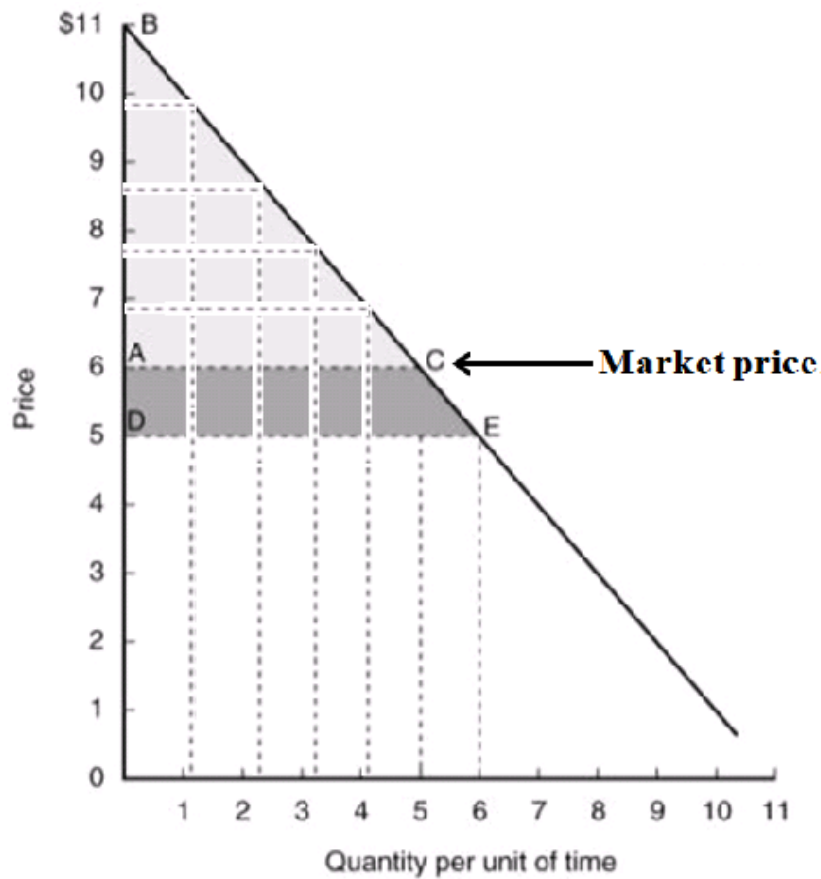
Potential buyer's willing to pay a higher price for a lesser quantity, but do not have to given the level of supply coming onto the market in a given period.

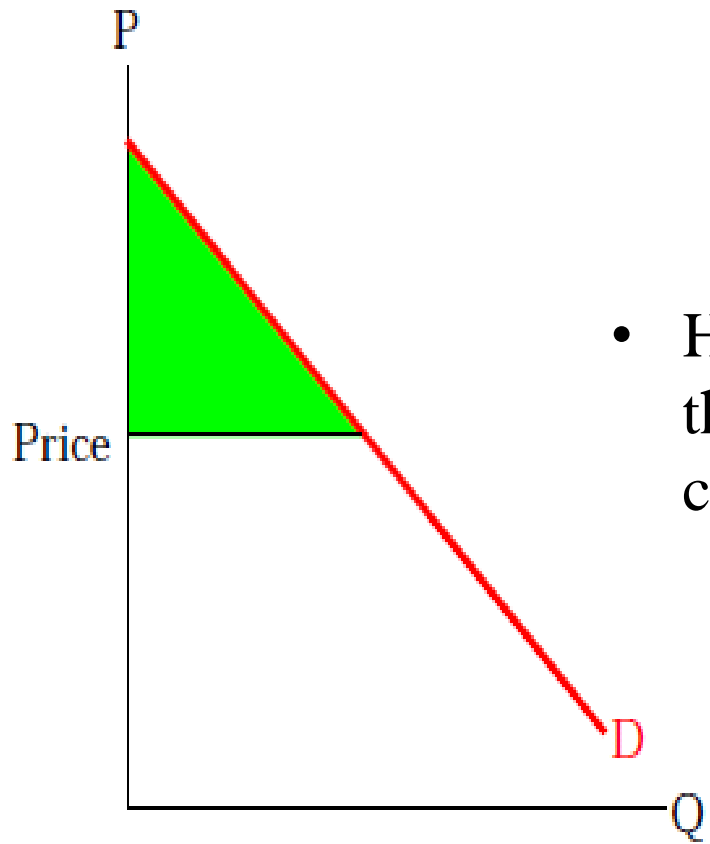
- It is the difference between willingness to pay much more to purchase a smaller quantity and the mount actually paid.



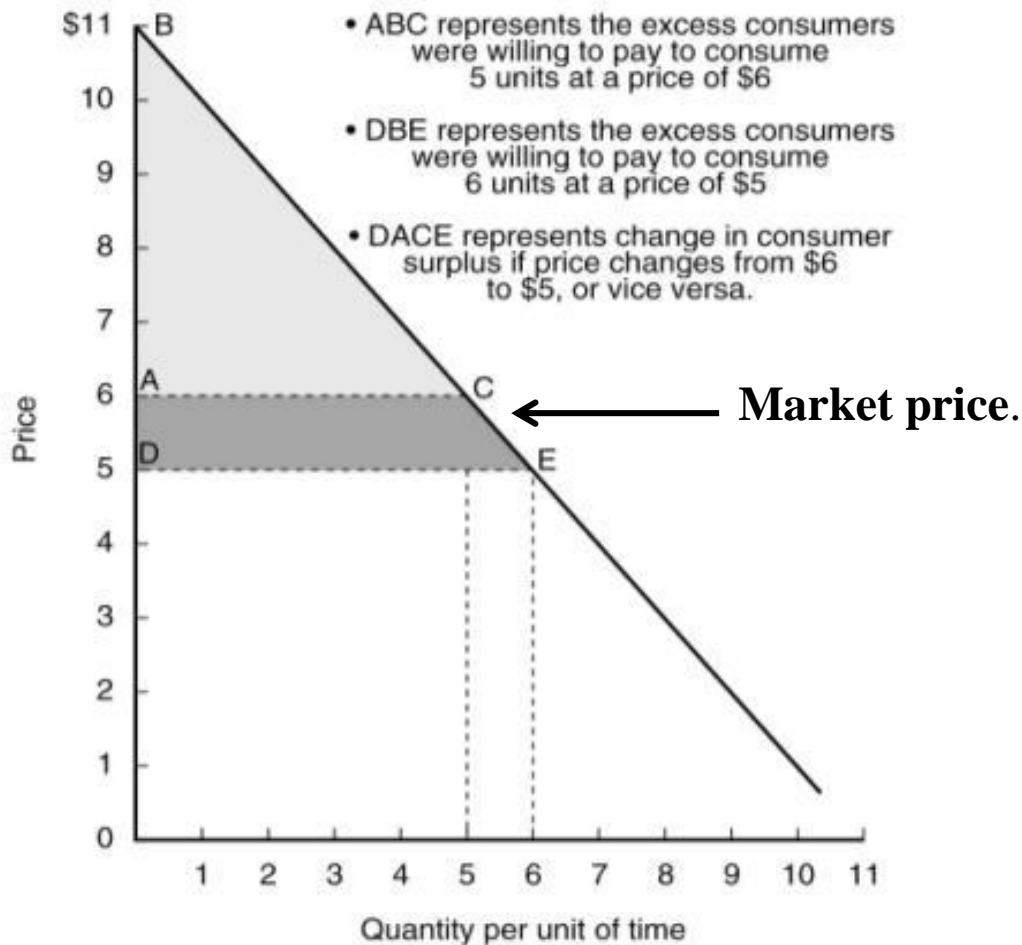
- Consumer surplus is the net benefit buyers enjoy from purchasing and consuming the good.

Individual consumer surplus is the net gain to an individual buyer from the purchase of a good.





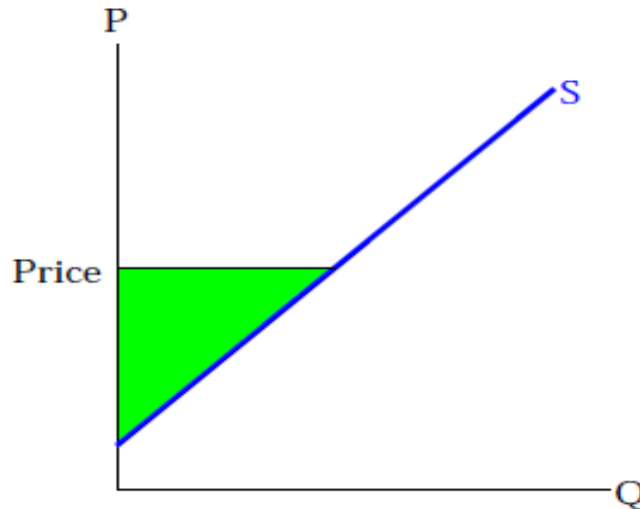
- Height of market demand curve reflects the benefit a buyer enjoys from consuming a specific unit of the good.



Total consumer surplus in a market is the sum of the individual consumer surpluses of all the buyers of a good. It is the area under the demand curve above the market price.

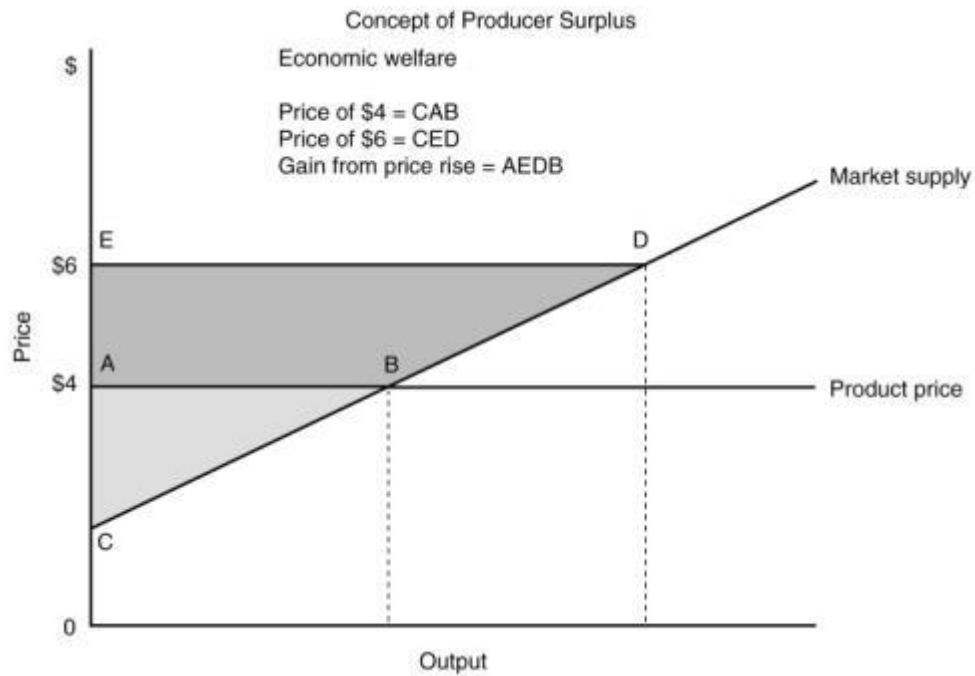
Producer surplus

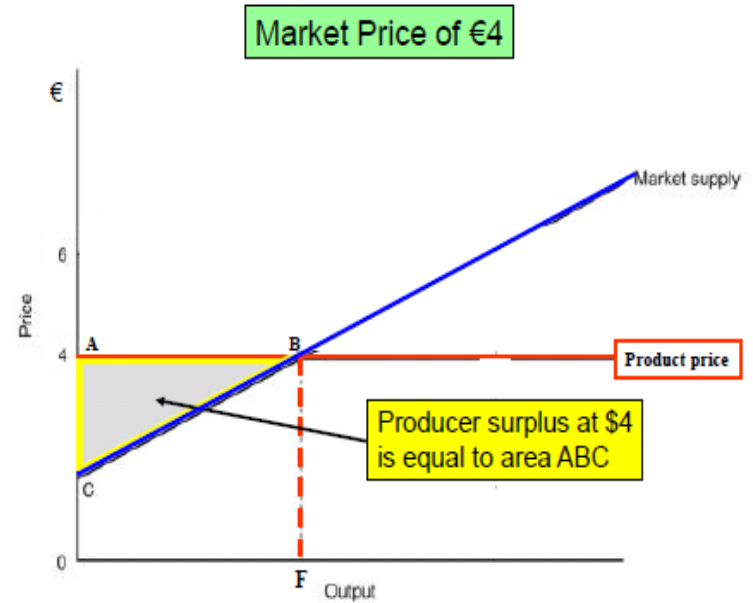
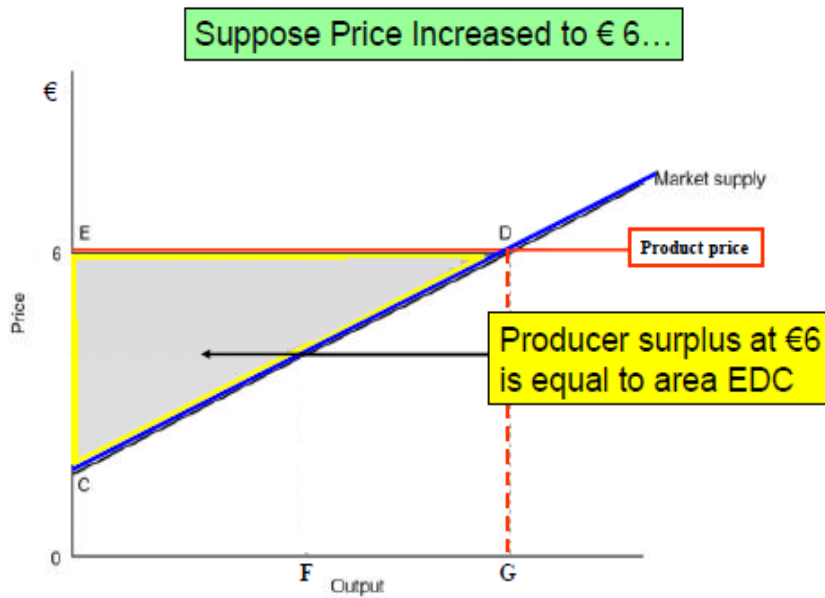
- A potential seller's **cost is the lowest price** at which he or she is willing to sell a good.
- Producer surplus is equal to the difference between the price received and the seller's cost. It is a term economists use for profit.



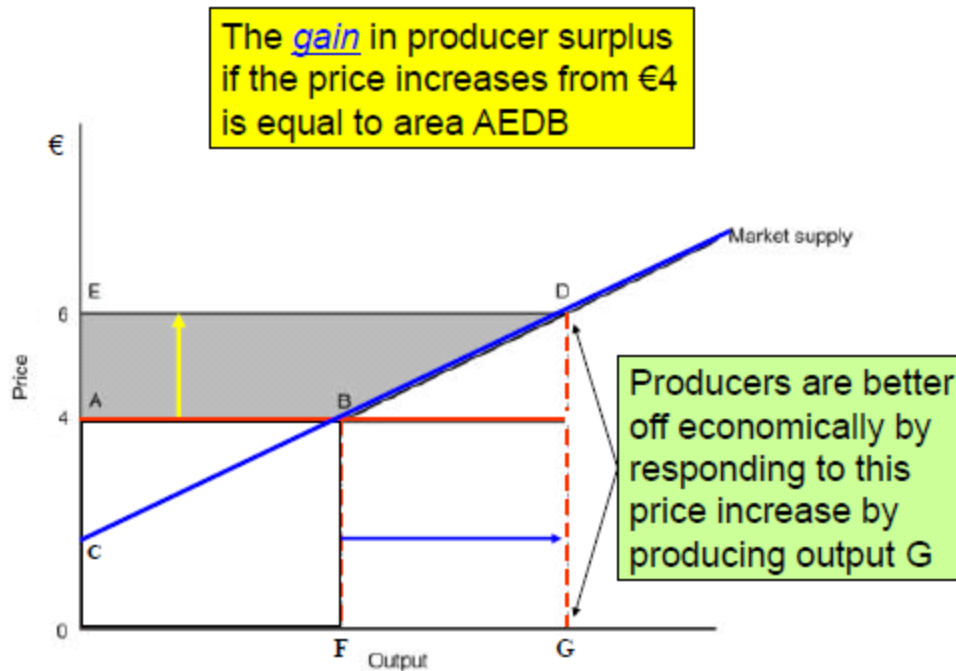
- The total producer surplus from sales of a good at a given price is the area above the supply curve but below market price .

Producer Surplus: The net benefit sellers enjoy from producing and selling the good.

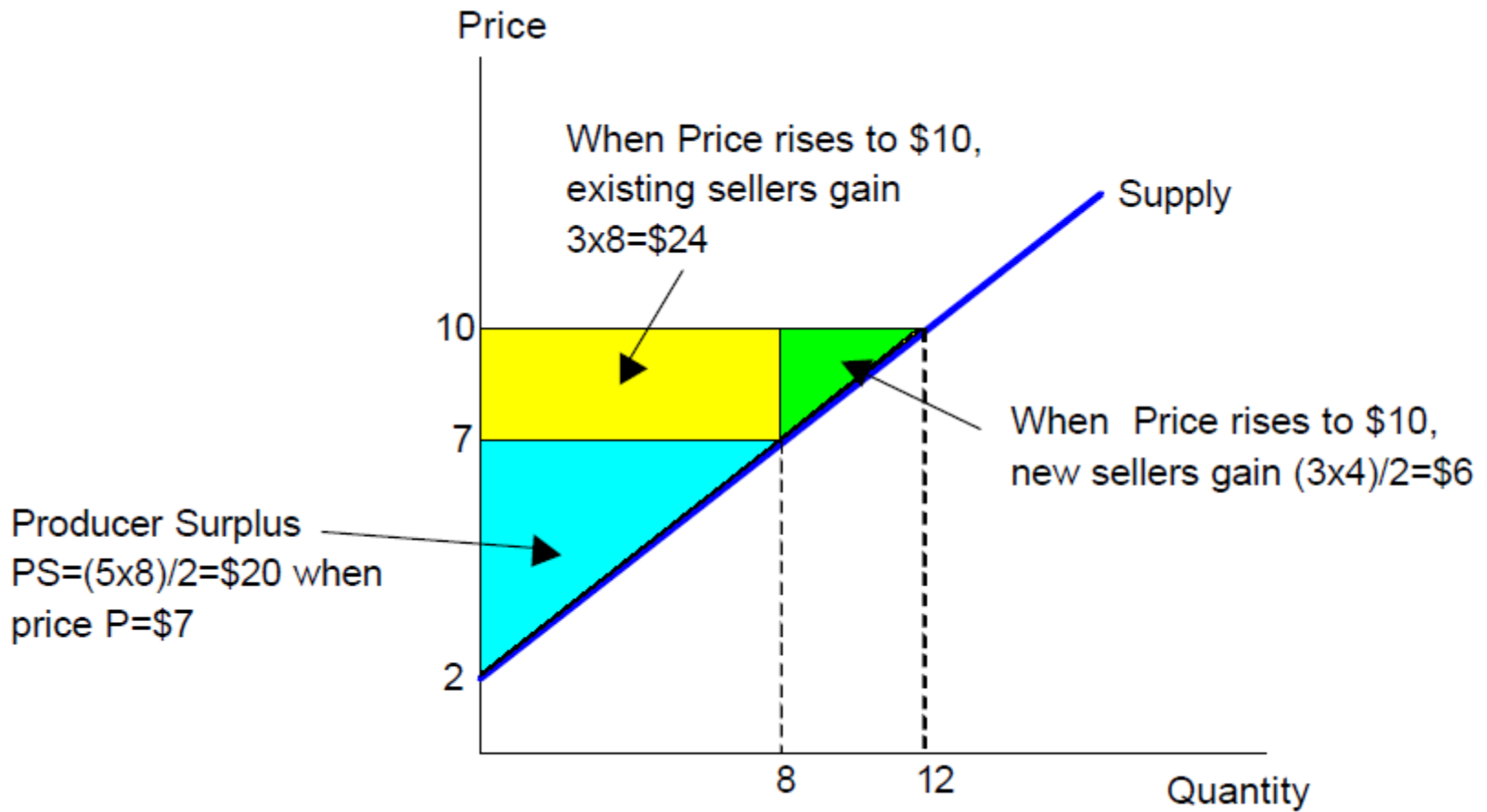




- Individual producer surplus is the net gain to a seller from selling a good.



- **Total producer surplus in a market is the sum of the individual producer surpluses of all the sellers of a good.**
- The total surplus generated in a market is the total net gain to consumers and producers from trading in the market.
- Total economic surplus is therefore equal to consumer surplus *plus producer surplus*.



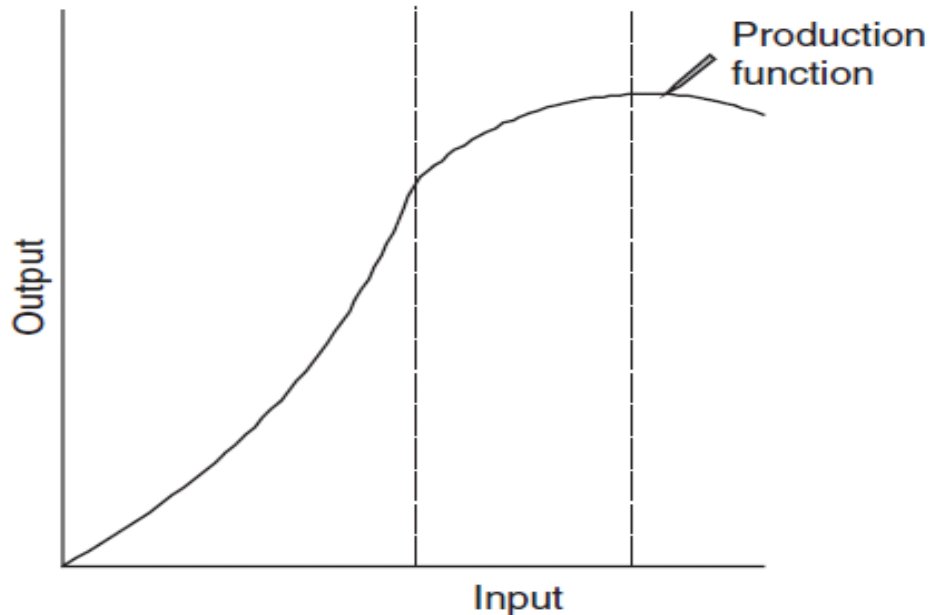
Questions

3. Production analysis/economics

3.1. Relationship between inputs and out puts

Production function

- It reflects input-output relationship and the concepts of average and marginal product.



- Characterized by physical relationship between the use of inputs and the level of outputs.

Ex. Physical relationship between yields and fertilizer use.

- Where there are n number of identifiable inputs, a production function may be expressed as

$$\text{Output} = f(\text{Q input 1}, \text{Q input 2}, \dots \text{Q input n})$$

- If one input in a production is varied , and all the other inputs are held fixed at their existing level, we can write it as

Output = f(labor| capital, land and management)

The bar indicates that only the first input (labor) is being varied.

- This enables to examine the relationship between the first input and output opposed to other inputs.

Example: In a hypothetical firm TOP-AG, labor varied **all other inputs capital, land and management are fixed at their current levels**. If daily labor use is 10hrs a day in column 2, the level of output would be 1 unit.

Table 6.1 Production Relationship for TOP-AG, Inc.

Point on Figure 6.1	(1) Daily Labor Use	(2) Daily Output Level	(3) Marginal Physical Product, $\Delta(2) \div \Delta(1)$	(4) Average Physical Product, $(2) \div (1)$
A	10.0	1.0		.10
B	16.0	3.0	.33	.19
C	20.0	4.8	.45	.24
D	22.0	6.5	.85	.30
E	26.0	8.1	.40	.31
F	32.0	9.6	.25	.30
G	40.0	10.8	.15	.27
H	50.0	11.6	.08	.23
I	62.0	12.0	.03	.19
J	76.0	11.7	-.02	.15

What is **marginal** in economics?

- Marginal analysis
- Marginal benefit
- Marginal revenue
- Marginal physical product
- Marginal cost
- etc

Concept of marginal analysis

- **Margin = basics of economics**
- **Marginal analysis** is the process of comparing the marginal benefit to the marginal cost in order to figure out if adding one extra unit is worth it.
- Marginal analysis means we look at the last unit of consumption/cost. A choice at the margin is a decision to do a little more or a little less of something.
- Companies use marginal analysis as a decision-making tool to help them maximize their potential profits.
- Economists argue that most choices are made “at the margin” which is the current level of an activity.

- Marginal analysis supports decision-making based on marginal or incremental changes to resources instead of one based on totals or averages.
 - One more unit of input in production
 - Value of purchasing one more product
 - Effect of 1 % more tax on personal income
- Formula for marginal analysis:
Change in net benefits = marginal benefits - marginal cost.
- Marginal benefit, also known as marginal revenue, is the increase in total benefits as a result of a change in output of a good by one unit.

Example

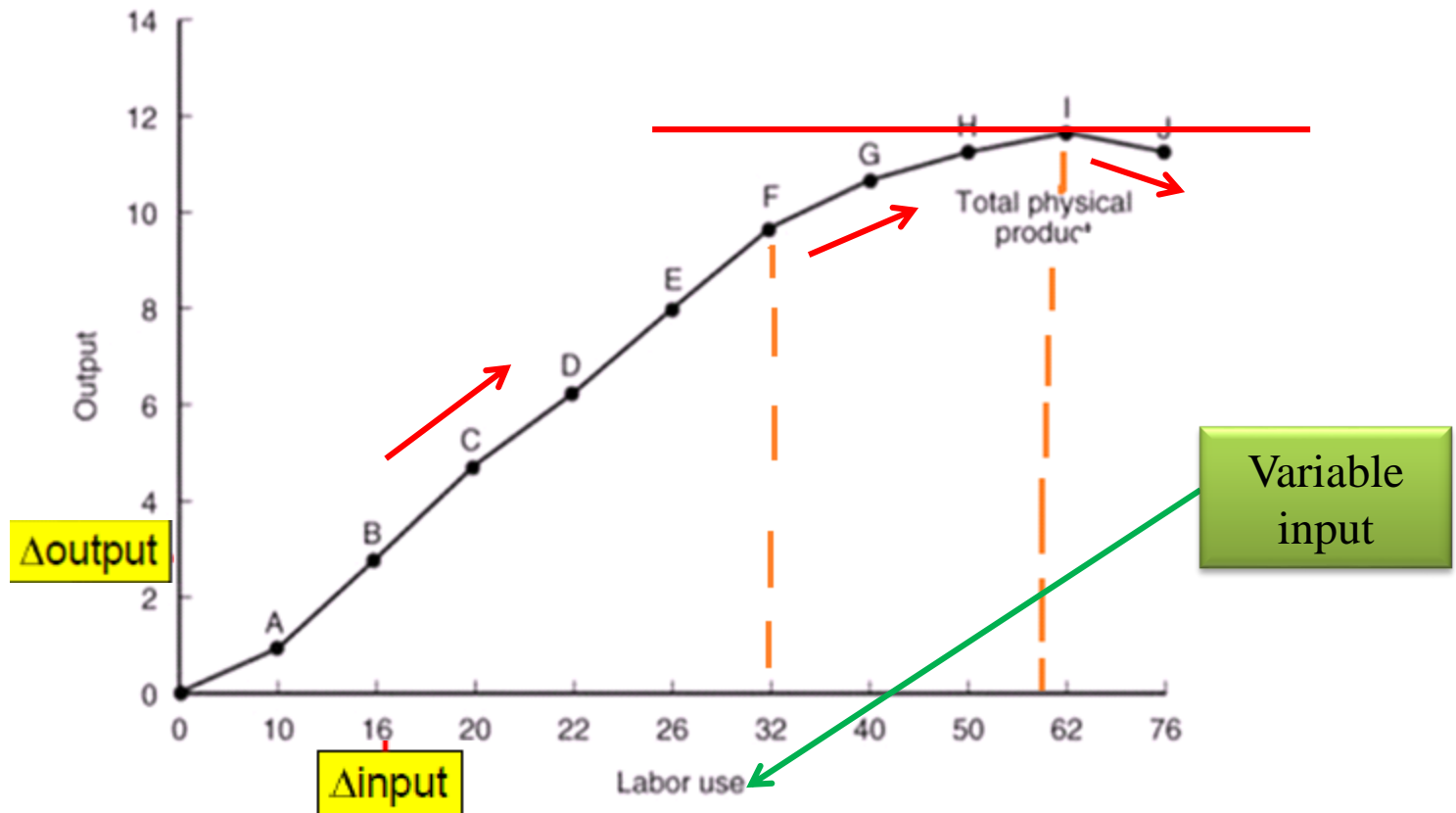
- Dawit, a HR manager in a company with six employees that sells sunglasses, wants to perform an analysis to develop an efficient compensation program.
- The analysis will provide information **on each employee's marginal cost and marginal benefit and** to determine which employees are profitable and which are not. Dawit creates a file for the six employees with the following information:

Marginal Analysis Example						
Employee	Units produced	Total Cost	Total Benefit	Marginal Cost	Marginal Benefit	Total Net Benefit
1	110	\$415	\$825	\$415	\$825	\$410
2	138	\$455	\$862	\$40	\$37	\$407
3	212	\$742	\$1,590	\$287	\$728	\$848
4	213	\$888	\$1,642	\$146	\$52	\$754
5	315	\$1,103	\$2,363	\$215	\$721	\$1,260
6	458	\$1,251	\$3,435	\$149	\$1,073	\$2,184
	1,446	\$4,854	\$10,717	\$1,251	\$3,435	\$5,863

- The employees who are profitable create more value than their compensation, whereas the loss-making employees create less value than their compensation.
- **Conclusion:** Employee 2 and employee 4 are creating less value than their compensation as the marginal cost is higher than the marginal benefit. In this case, Dawit must determine how he should allocate the scarce resource so that these two employees perform at a level that marginal benefit equals marginal cost or exceeds it.

Total physical product

- TPP is the r/p b/n output and one input, holding other inputs in the production function constant.



- TPP initially increase at increasing rate, then increase at a decreasing rate and crosses the horizontal axis (i.e. negative) when it reached its peak,, and finally begins to decline (decrease) over a full range of potential input use levels.

Marginal physical product

Marginal physical product (marginal product) for an input is the change in the level of output associated with a change in the use of a particular input, where all other inputs used in the production process remain fixed at their existing levels.

$$\text{marginal physical product} = \frac{\Delta \text{ output}}{\Delta \text{ input}}$$

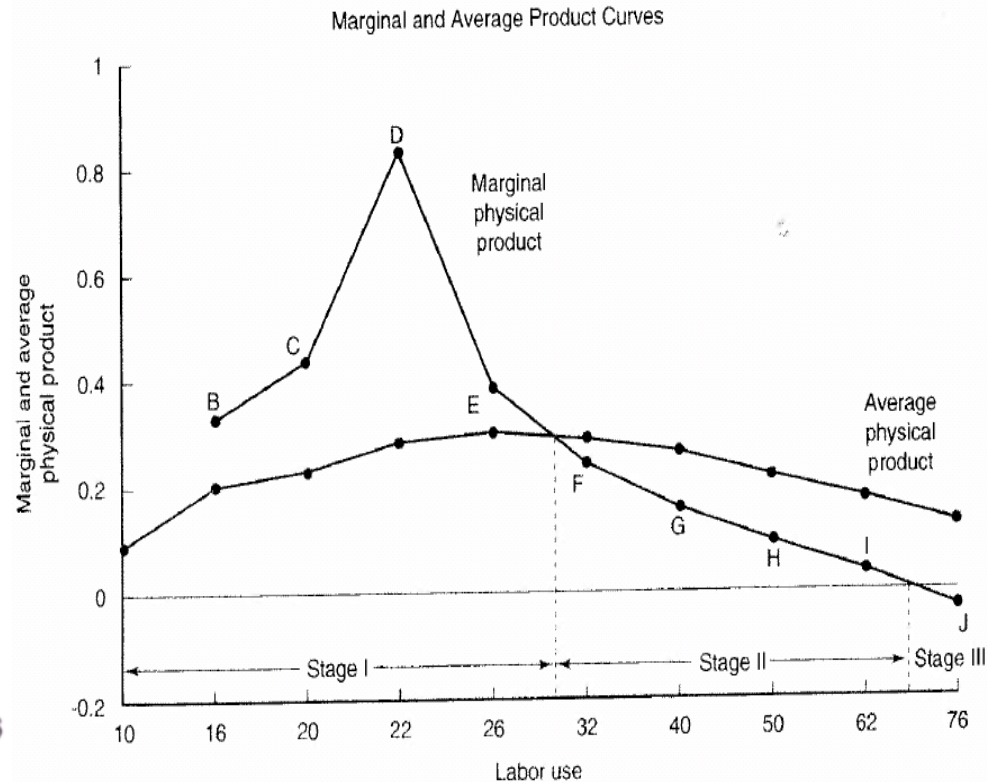
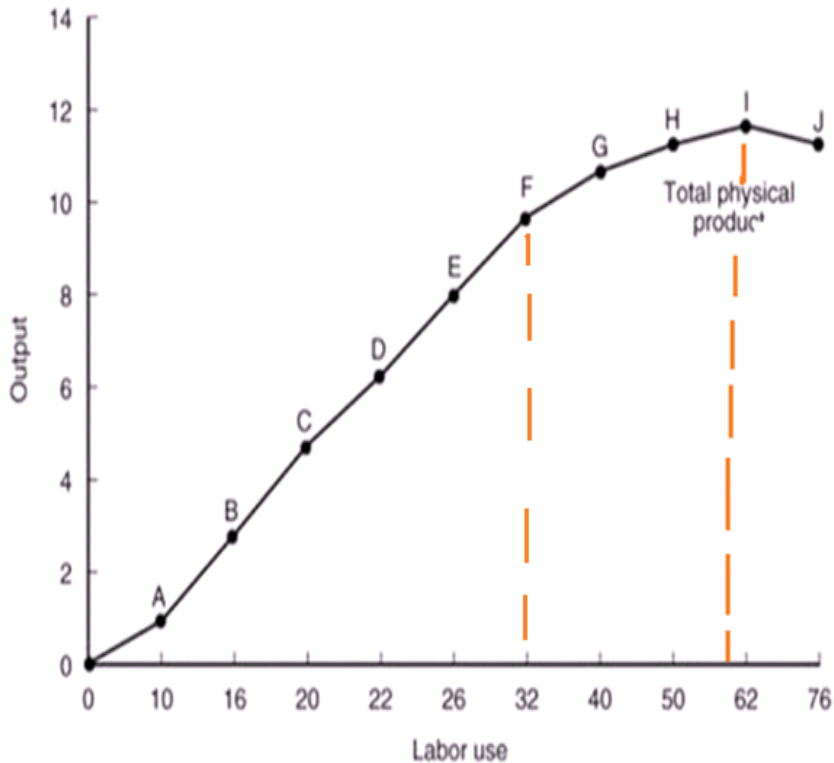
Point on Figure 6.1	(1) Daily Labor Use	(2) Daily Output Level	(3) Marginal Physical Product $\Delta(2) \div \Delta(1)$
A	10.0	1.0	
B	16.0	3.0	.33

Marginal revenue

- It is the change in total revenue. It represents the change in revenue from producing more output. Under conditions of perfect competition, it is price the producer receives from the market.

$$\text{Marginal revenue} = \frac{\Delta \text{ Total revenue}}{\Delta \text{ Output}}$$

Stages of production



Stage I: The point at which the APP curve rising and the MPP curve lies above the APP curve.

Stage II: The point use begins at the end of **stage I**, the APP curve falling. MPP continuous until the value becomes **equals to zero**. It represents the range of interest to economists.

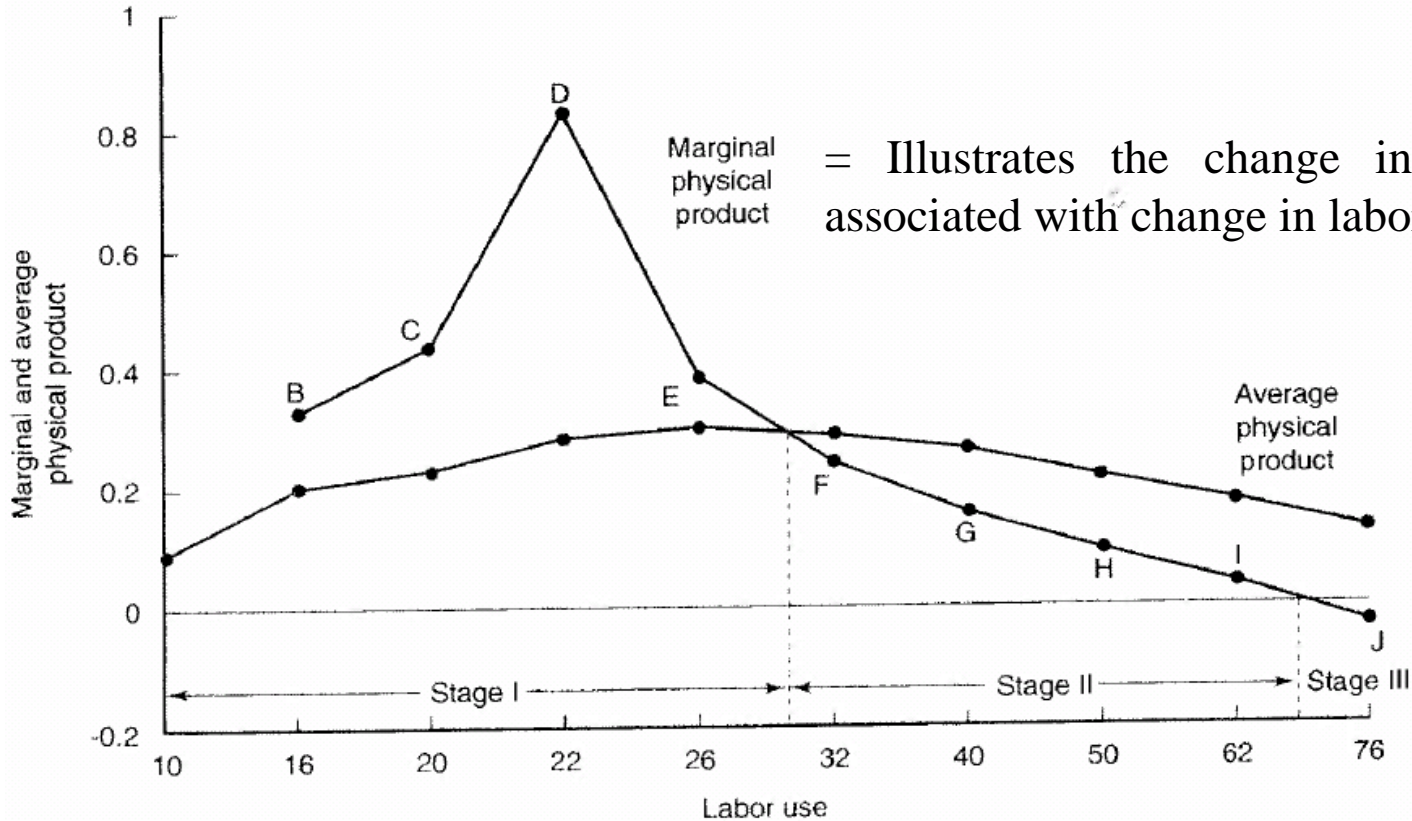
Law of diminishing marginal returns

- *The MPP of labor is falling throughout stage II. It is frequently observed that it is a law – the **law of diminishing marginal returns states that** “as successive units of a variable input are added to a production process with the other inputs held constant, the **MPP** eventually declines”.*

Stage III: The point at which input use lies to the right of stage II, or at which the MPP is negative.

Why stop in **stage I** and why produce in **stage III**. *Stopping production at stages I and II is **irrational**. As long as the average physical product is rising, you should expand input use.*

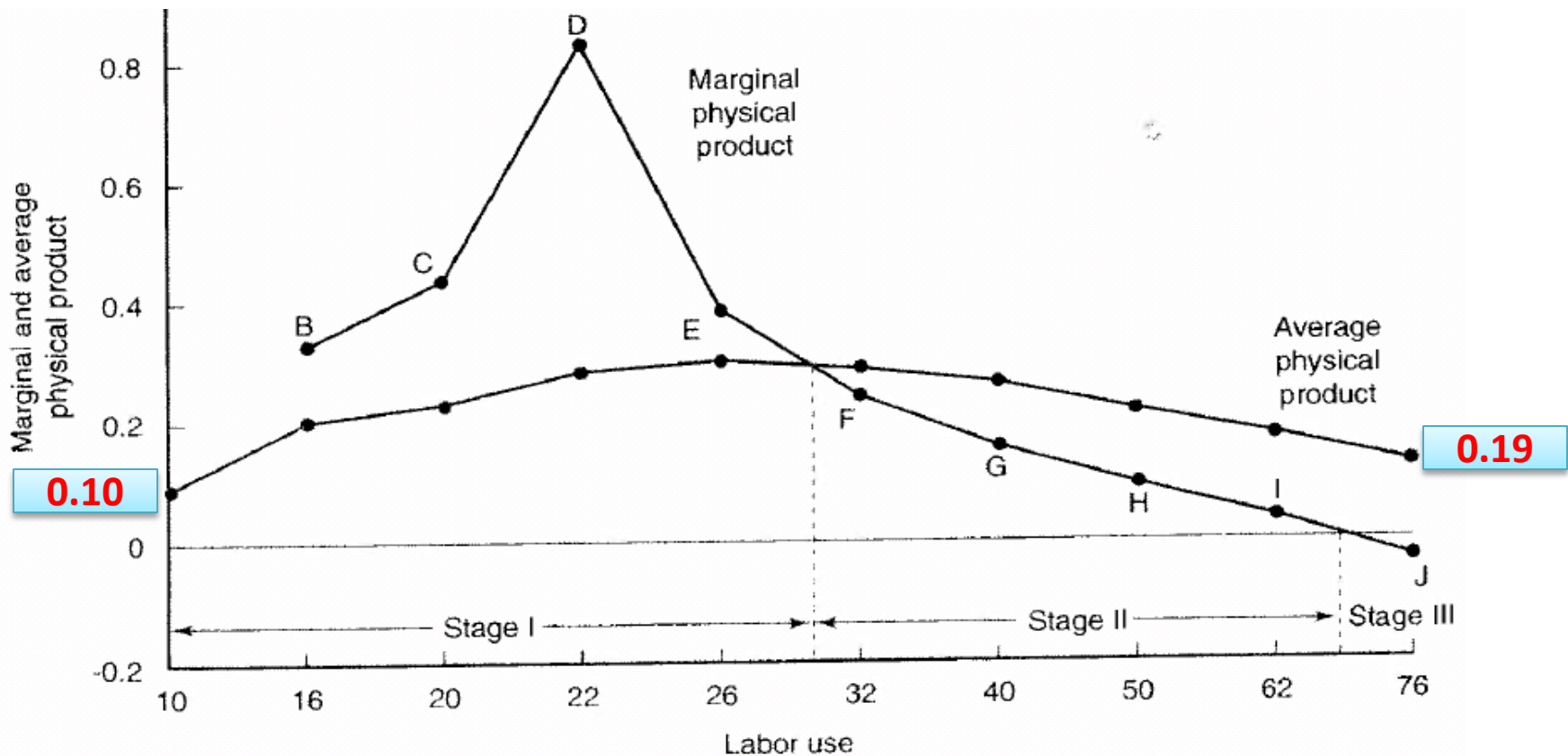
Marginal and Average Product Curves



= Illustrates the change in output associated with change in labor input.

- The MPP curve cuts the APP curve from above at the point where the APP curve reaches its maximum.

Point on Figure 6.1	(1) Daily Labor Use	(2) Daily Output Level	(3) Marginal Physical Product, $\Delta(2) \div \Delta(1)$	(4) Average Physical Product, $(2) \div (1)$
A	10.0	1.0		.10
B	16.0	3.0	.33	.19
C	20.0	4.8	.45	.24
D	22.0	6.5	.85	.30
E	26.0	8.1	.40	.31
F	32.0	9.6	.25	.30
G	40.0	10.8	.15	.27
H	50.0	11.6	.08	.23
I	62.0	12.0	.05	.19
J	76.0	11.7	-.02	.15



Laws of Returns

Law of increasing marginal returns (productivity)

- It is said to operate when each marginal unit of variable input **adds more and more quantity of output to the total output**. It is not common in agriculture, e.g. small increase in seed input given the fixed inputs.

Seed (X) (in kg)	Total Product (Y) (in kg)	Marginal Product (Returns) ($\Delta Y/\Delta X$)
10	1000	-
15	1025	5
20	1075	10
25	1150	15
30	1250	20
35	1375	25

Algebraically, $\Delta Y_1/\Delta X_1 < \Delta Y_2/\Delta X_2 < \dots < \Delta Y_n/\Delta X_n$

Remember stage I of production

Law of constant marginal returns (productivity)

- It is said to operate when each marginal unit of variable input **adds equal quantity of output to the total output**. It is applicable over limited range, e.g. one tractor (plus driver) will almost give same output, other things remaining constant.

Fertilizer (X) (in kg)	Total Product (Y) (in kg)	Marginal Product (Returns) ($\Delta Y/\Delta X$)
0	1300	-
10	1350	5
20	1400	5
30	1450	5
40	1500	5
50	1550	5

- Algebraically, $\Delta Y_1/\Delta X_1 = \Delta Y_2/\Delta X_2 = \dots = \Delta Y_n/\Delta X_n$

Law of decreasing marginal returns (productivity)

- It is said to operate when each marginal unit of variable input adds less and less quantity of output to the total output. Law of diminishing marginal returns. **It is widely applicable in agriculture.**

Fertilizer (X) (in kg)	Total Product (Y) (in kg)	Marginal Product (Returns) ($\Delta Y/\Delta X$)
0	500	-
10	1400	90
20	2100	70
30	2600	50
40	3000	40
50	3300	30
60	3500	20

- Algebraically, $\Delta Y_1/\Delta X_1 > \Delta Y_2/\Delta X_2 > \dots > \Delta Y_n/\Delta X_n$

Questions

Costs of production

What are costs?

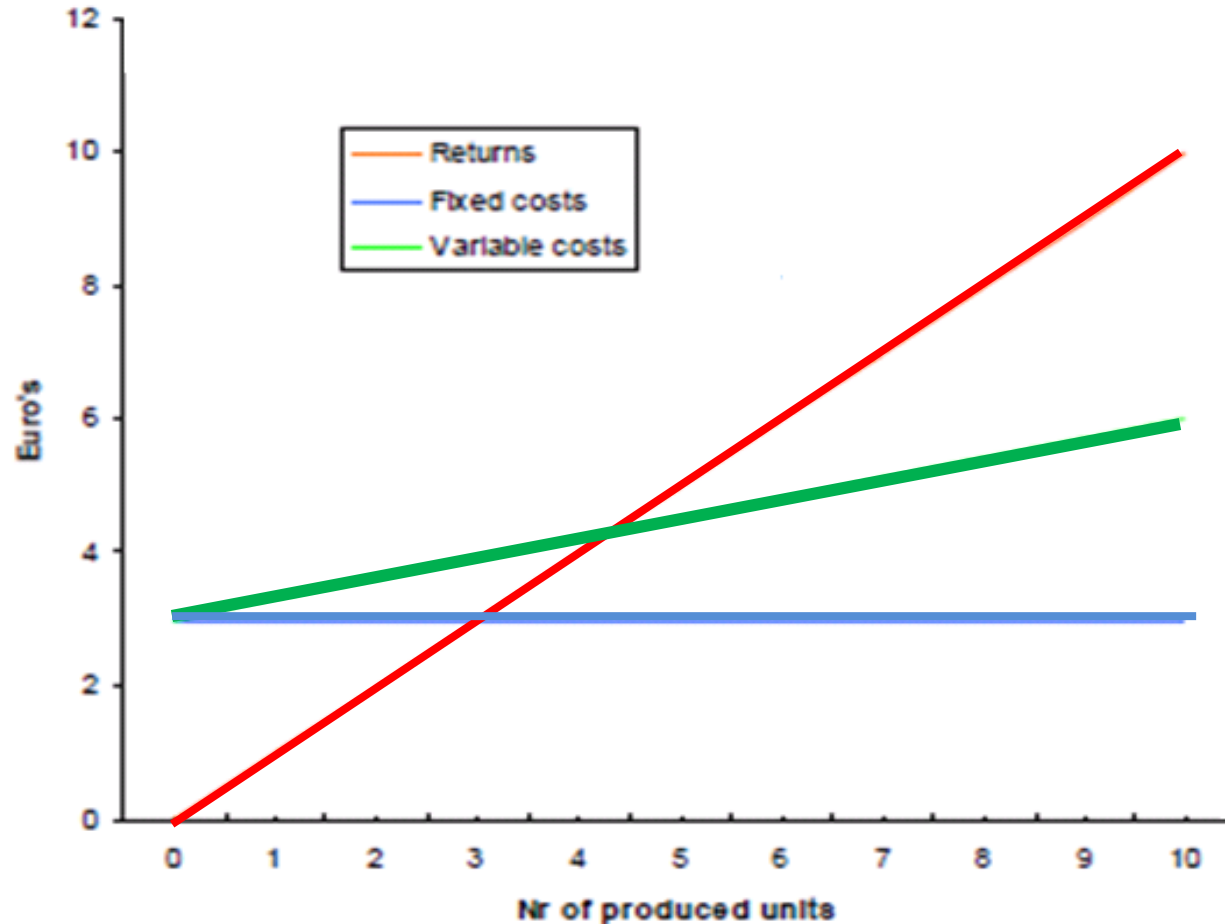
- Costs exist if “something” is used that has *value and is scarce*
- Value (economic definition): “something” has value when it contributes to fulfillment of needs.

Although knowledge of the production relationships is extremely important, **we must also know the costs of production.**

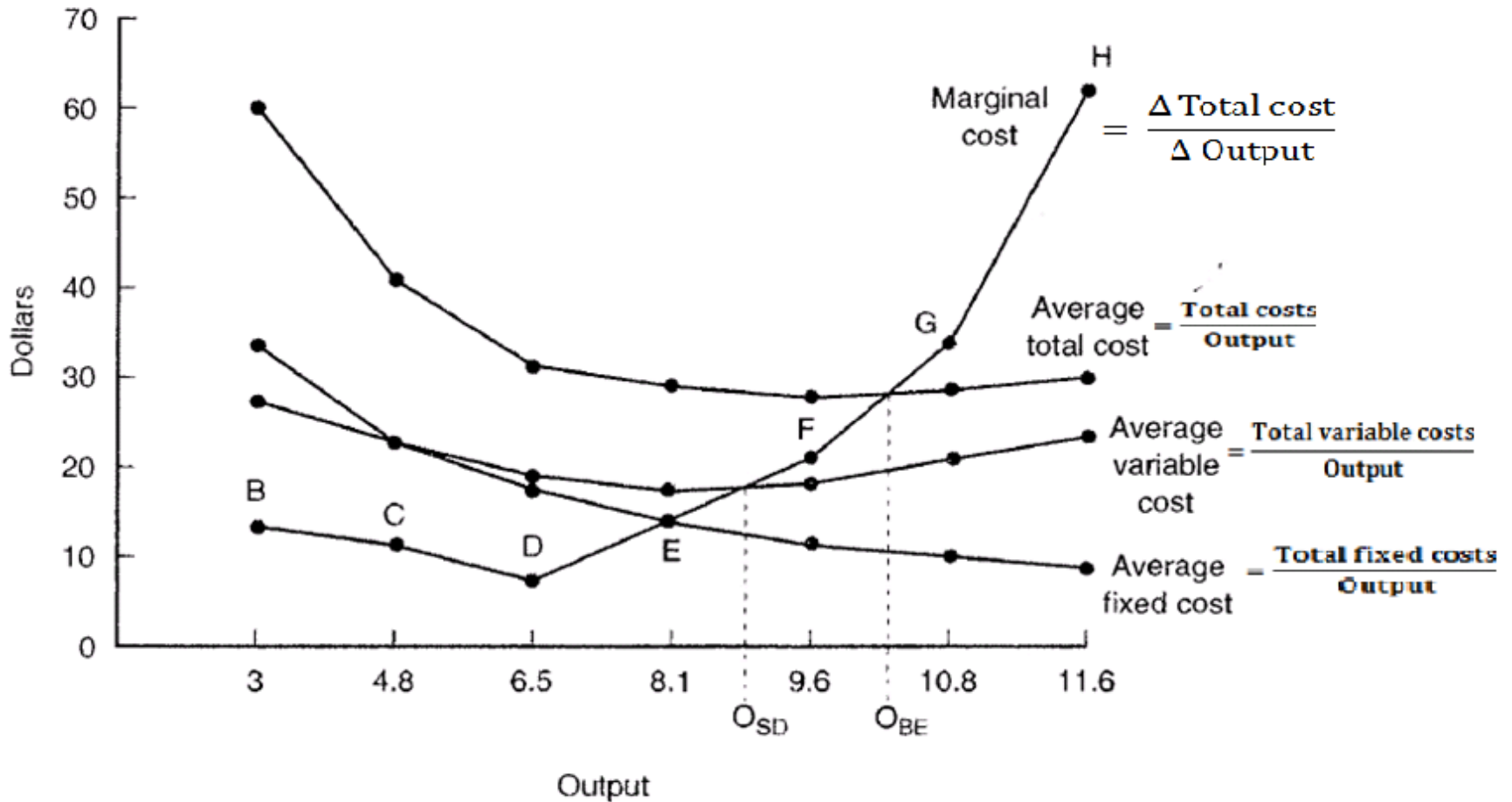
Total costs of production

- Total costs of production is the costs associated with the use of all inputs to production. Costs can be divided into **fixed costs** and **variable costs**.

- 1. Fixed costs:** Costs that do not vary with increasing production, depends on production capacity (e.g fixed costs. land, buildings, equipment/machines. There is a maximum. At a certain moment you have to increase fixed costs: **large step**.



- 2. Variable costs:** costs that vary with increasing level of production within a certain production capacity (level of production). Ex of variable costs: feed, veterinary costs, breeding costs, cleaning costs, etc



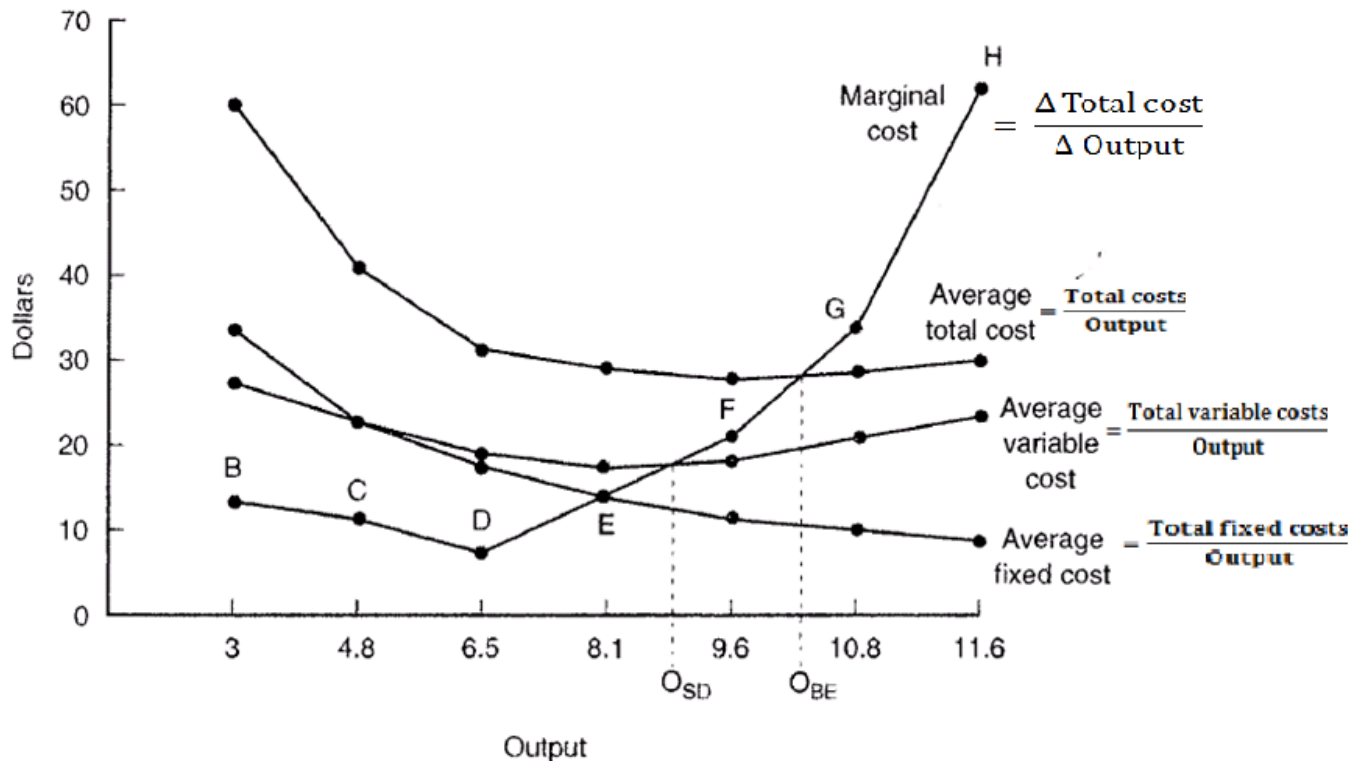
Average fixed costs decline over the entire range of production b/s they do not vary with output.

Average variable costs decrease up to a certain output level then increase when output expands further.

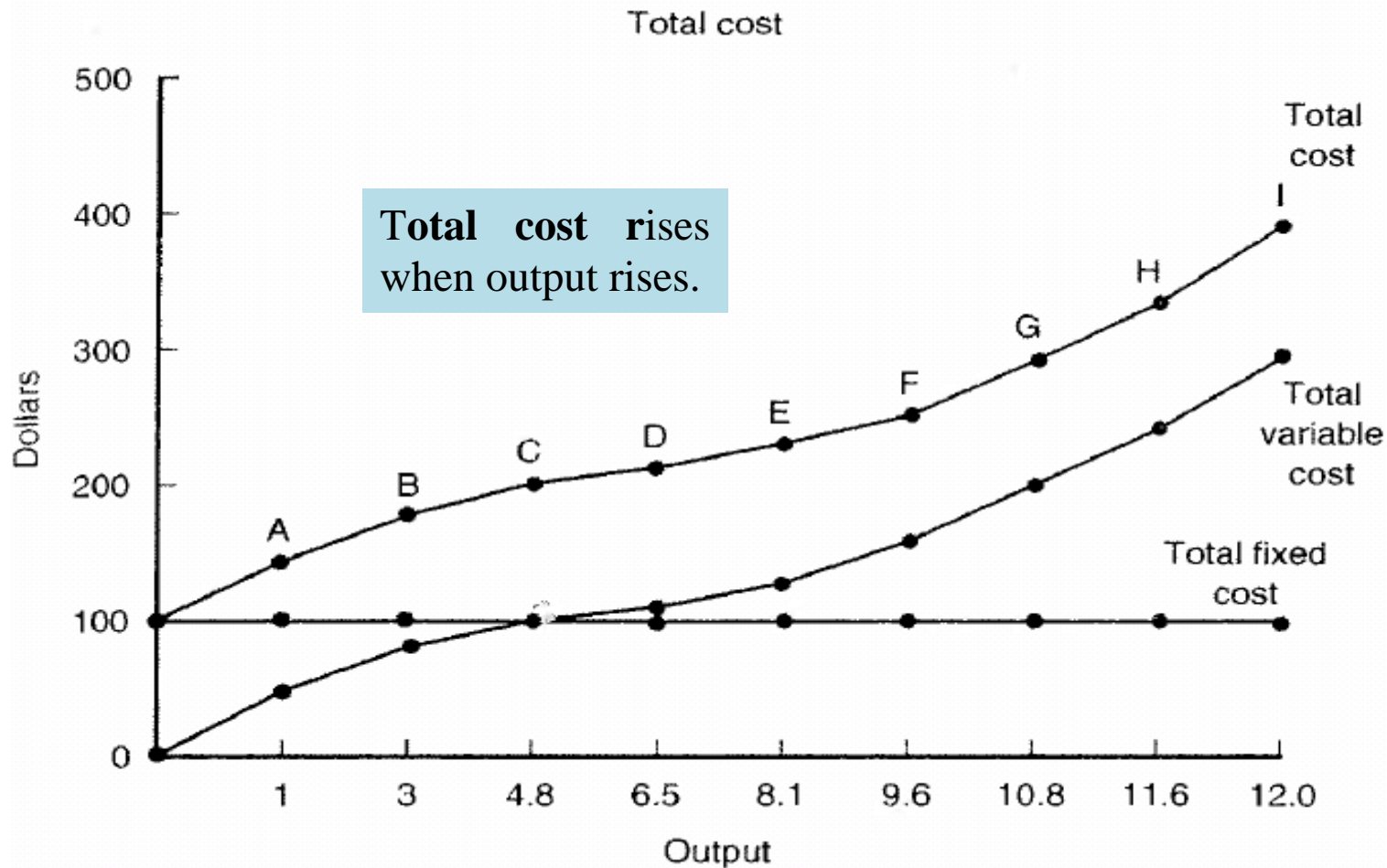
Marginal cost

- Marginal cost is the change in the business's total costs per unit of change in output. It also represents the slope of the total cost and total variable cost curves.

$$\text{Marginal cost} = \frac{\Delta \text{Total cost}}{\Delta \text{Output}}$$



Total fixed cost curve is parallel to the horizontal axis, thus illustrating its fixed nature when output rises.



Total cost rises when output rises.

The constant gap between the **total cost** curve and **total variable cost** curve is due to the fixed cost, which is equal to 100 in this case.

The **total cost curve** which reflects both fixed and variable costs, rises when **output rises**.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Point on Figure 6.1	Total Output	Total Fixed Cost	Average Fixed Cost, $(2) \div (1)$	Total Variable Cost	Average Variable Cost, $(4) \div (1)$	Total Cost, $(2) + (4)$	Marginal Cost, $\Delta(6) \div \Delta(1)$	Average Total Cost, $(3) + (5)$
A	1.0	100.00	100.00	50.00	50.00	150.00		150.00
B	3.0	100.00	33.33	80.00	26.67	180.00	15.00	60.00
C	4.8	100.00	20.83	100.00	20.83	200.00	11.11	41.67
D	6.5	100.00	15.38	110.00	16.92	210.00	5.88	32.31
E	8.1	100.00	12.35	130.00	16.05	230.00	12.50	28.40
F	9.6	100.00	10.42	160.00	16.67	260.00	20.00	27.08
G	10.8	100.00	9.26	200.00	18.52	300.00	33.33	27.78
H	11.6	100.00	8.62	250.00	21.55	350.00	62.50	30.17
I	12.0	100.00	8.33	310.00	25.83	410.00	150.00	34.17
J	11.7	100.00	8.55	380.00	32.48	480.00	n/a	41.03

Complete cost schedule for the hypothetical example

Total physical product

Total fixed costs divided by total output

Total variable costs divided by total output

Change total costs associated with a change in total output

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Point on Figure 6.1	Total Output	Total Fixed Cost	Average Fixed Cost, $(2) \div (1)$	Total Variable Cost	Average Variable Cost, $(4) \div (1)$	Total Cost, $(2) + (4)$	Marginal Cost, $\Delta(6) \div \Delta(1)$	Average Total Cost, $(3) + (5)$
A	1.0	100.00	100.00	50.00	50.00	150.00		150.00
B	3.0	100.00	33.33	80.00	26.67	180.00	15.00	60.00
C	4.8	100.00	20.83	100.00	20.83	200.00	11.11	41.67
D	6.5	100.00	15.38	110.00	16.92	210.00	5.88	32.31
E	8.1	100.00	12.35	130.00	16.05	230.00	12.50	28.40
F	9.6	100.00	10.42	160.00	16.67	260.00	20.00	27.08
G	10.8	100.00	9.26	200.00	18.52	300.00	33.33	27.78
H	11.6	100.00	8.62	250.00	21.55	350.00	62.50	30.17
I	12.0	100.00	8.33	310.00	25.83	410.00	150.00	34.17
J	11.7	100.00	8.55	380.00	32.48	480.00	n/a	41.03

Fixed costs are €100 no matter the level of production

Costs that vary with level of production

Total fixed costs plus total variable costs

Total cost divided by total output or average variable costs plus average fixed costs

- Question

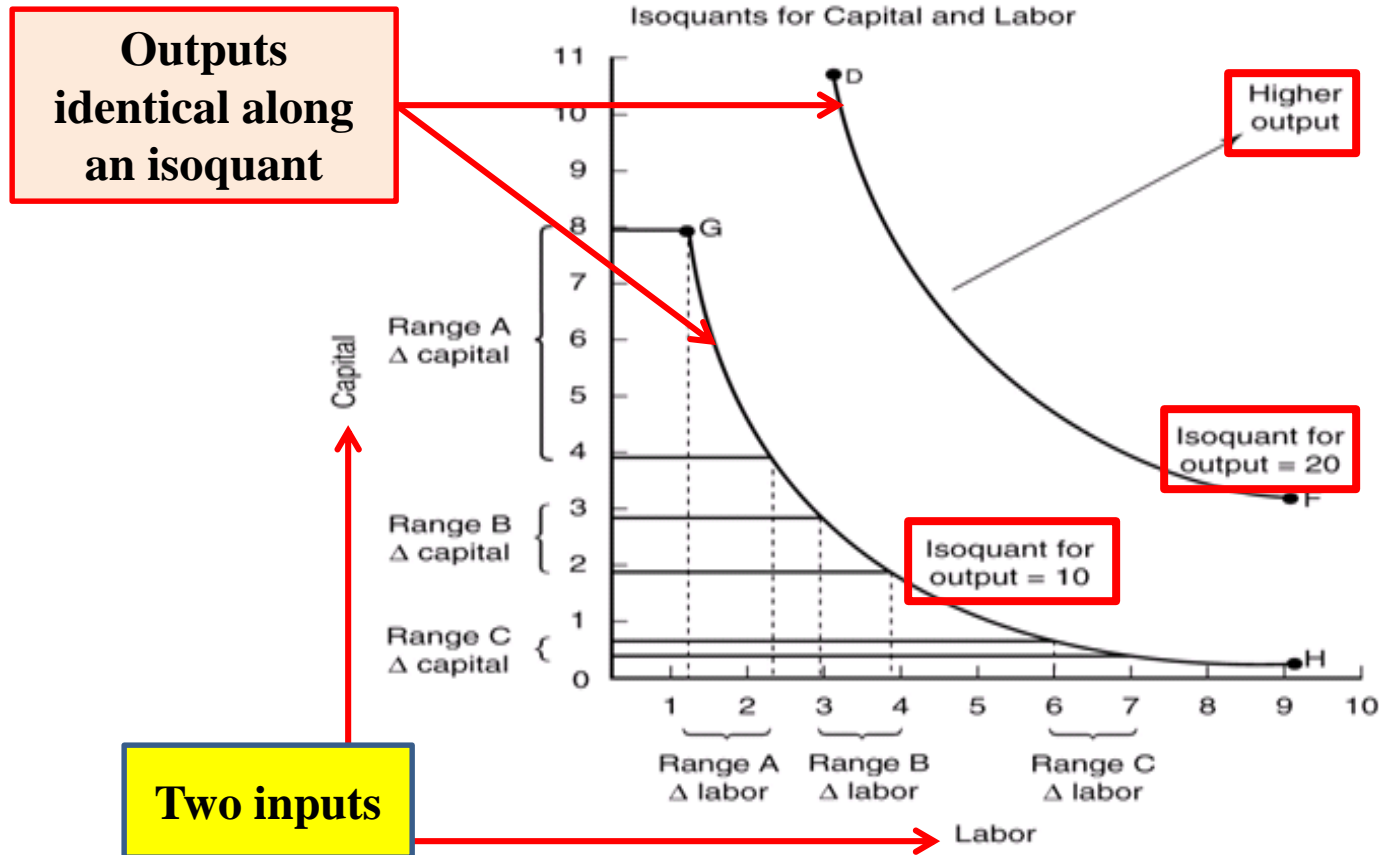
3.2. In put combination

Factor-Factor Relationship

- Factor-factor relationship is concerned with the possibilities of substituting one input/factor (X1) for another input/factor (X2) **for producing a given level of output.**
- A producer may have to use one or more inputs to produce one or more outputs. It is not only the **right kinds of inputs** but also their **optimum level** of use which will help to minimize the cost of production **without compromising on the level of output.**
- Factor-factor relationship is a question of identifying the **optimum** or **least-cost combination** of two or more resources to produce a certain amount of output.
- Therefore, the aims of factor-factor relationship is
 - 1) Minimization of cost of inputs at a given level of output.
 - 2) Optimization of output to the fixed factors through alternatives resources combinations.

Isoquant (Iso-product curve)

- It is defined as the locus of various combinations of two inputs yielding the same level of output.



- Each point on an isoquant represents the maximum output that can be attained with these input combinations.

- The slope of an isoquant (equal quantity) is referred to as the Marginal Rate of Technical Substitution, or MRTS. MRTS of capital for labor is given by:

$$\text{MRTS} = \Delta \text{Capital} \div \Delta \text{labor}$$

- If output remains unchanged along an isoquant, the loss in output from decreasing labor must be identical to the gain in output from adding capital.

Isoquants

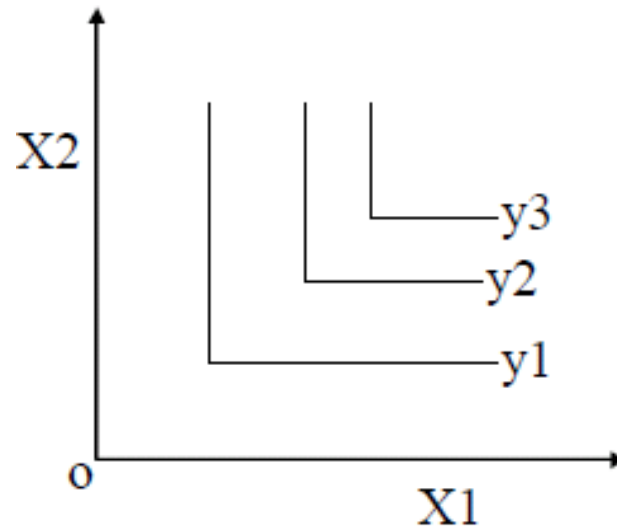
- have a negative slope,
- Isoquants to right indicate higher output level,
- do not intersect each other,
- are convex to origin showing diminishing MRTS.

The **shapes of isoquants** depend on the manner in which the variable inputs are combined to produce a particular level of output.

- (1) Fixed proportion combination of inputs,
- (2) Constant rate of substitution
- (3) Varying rates of substitution

Fixed proportion combination

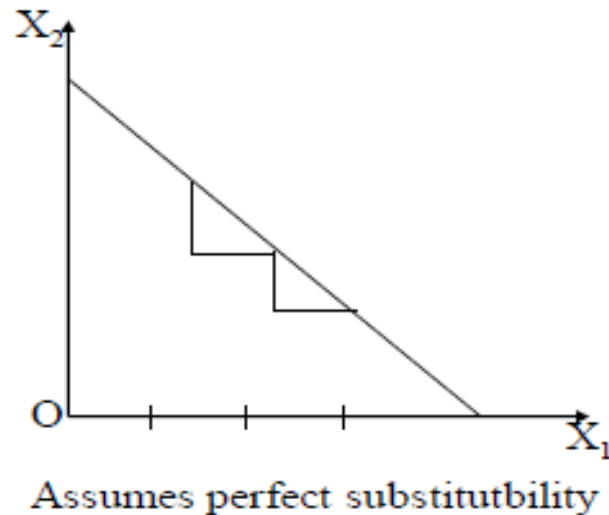
In this case products produced if **inputs are added in fixed proportion** at all levels of production. In this case there is **no substitution between inputs** and thus there is strict complementarity between the two inputs.



Such an isoquant implies that one exact combination of inputs will produce a particular level of output. The inputs which increase the output only when combined in a fixed proportion are known as **complementary inputs**.

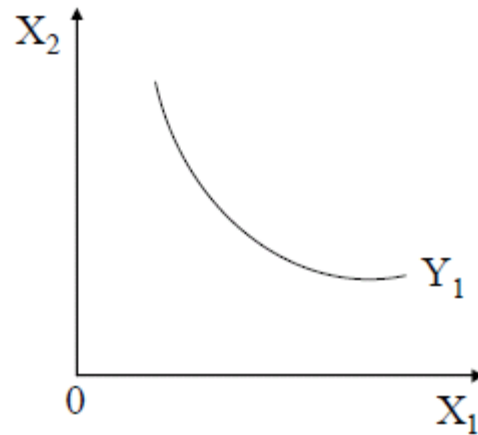
Constant rate of substitution

- The substitution occurs at constant rate i.e. the amount of one input replaced by the other input does not change as the added input increases. **Such type of a factor-factor relationship gives linear isoquants.**



Varying rate of substitution

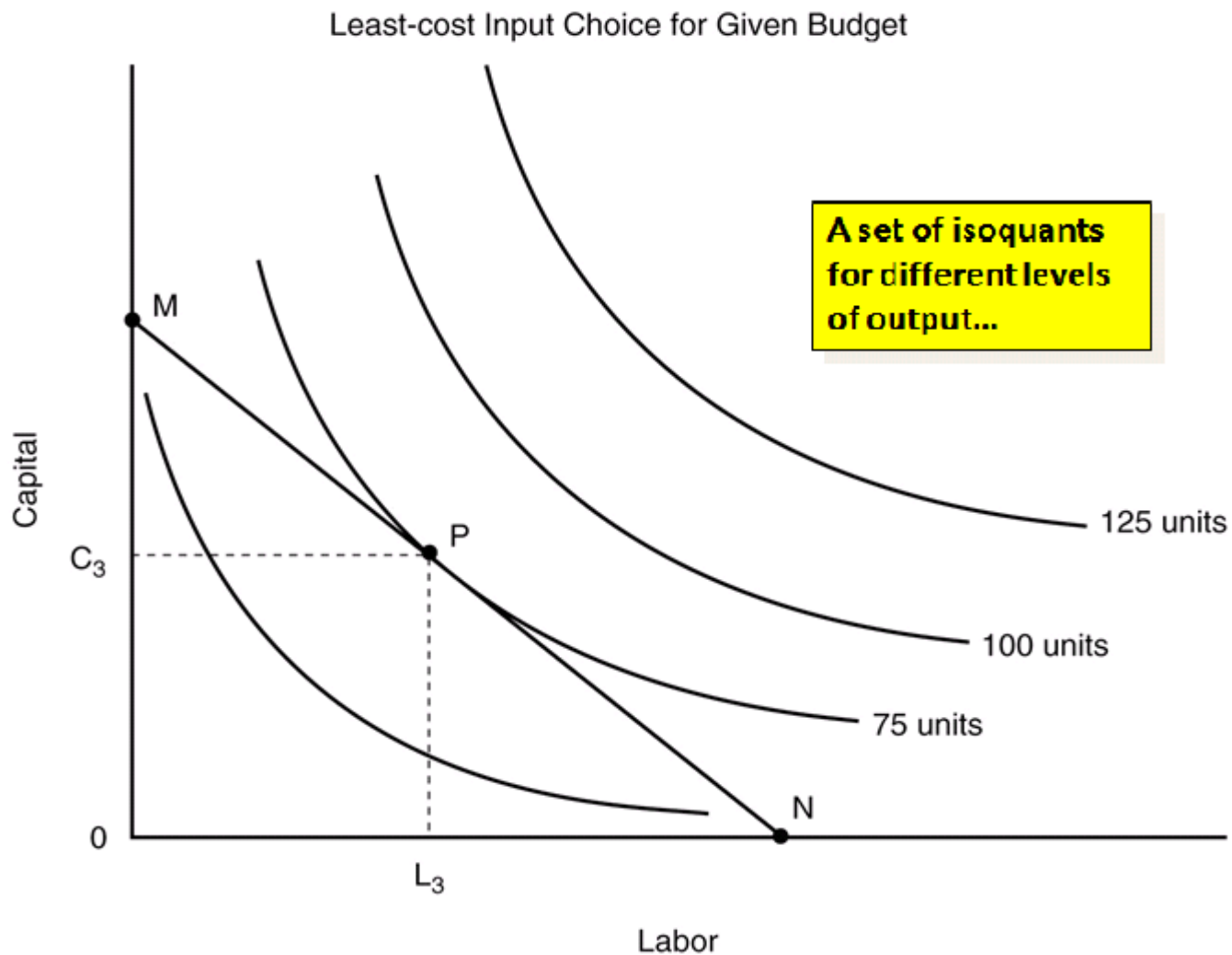
- In this case, there can either be **increasing rate** or **decreasing rate** of substitution. In this $MRTS_{X_1X_2}$ varies over iso-product curve.
- The amount of one input (X_1) required to substitute for one unit of another input (X_2) at a given level of production increases or decreases as the amount of X_1 used increases.
- These **convex isoquants** represent continuous substitution between the two inputs.

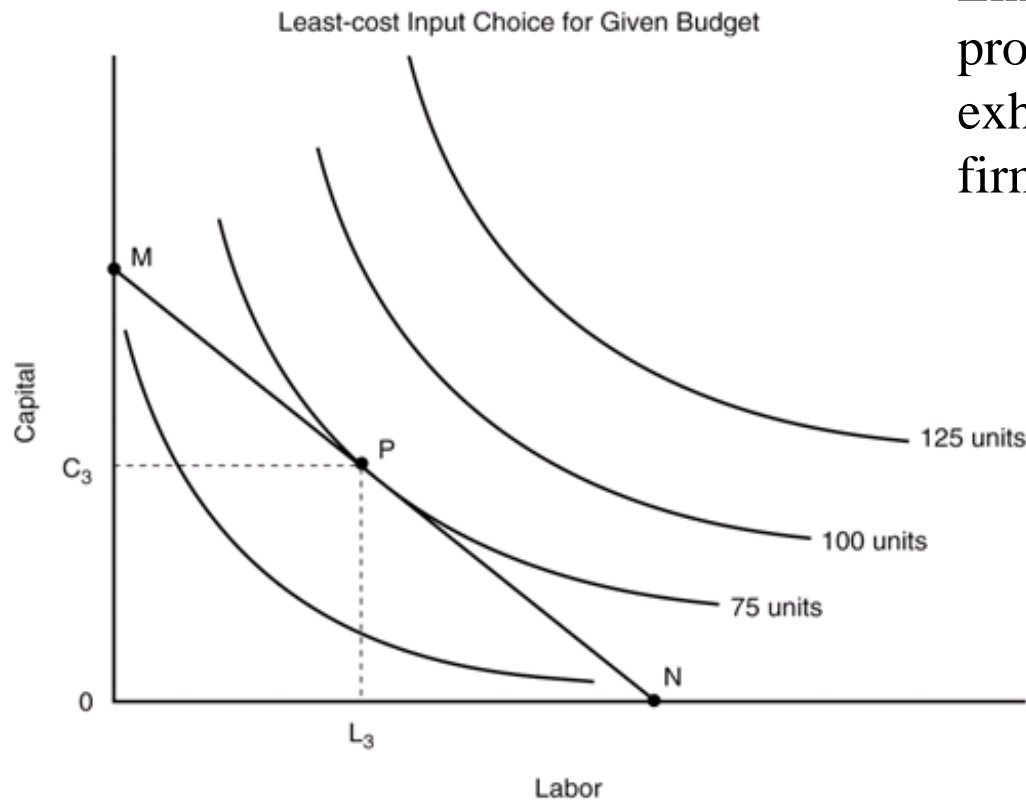


Fodder & concentrates

What Inputs to Use for a Specific Budget?

Least cost use of inputs for a given budget



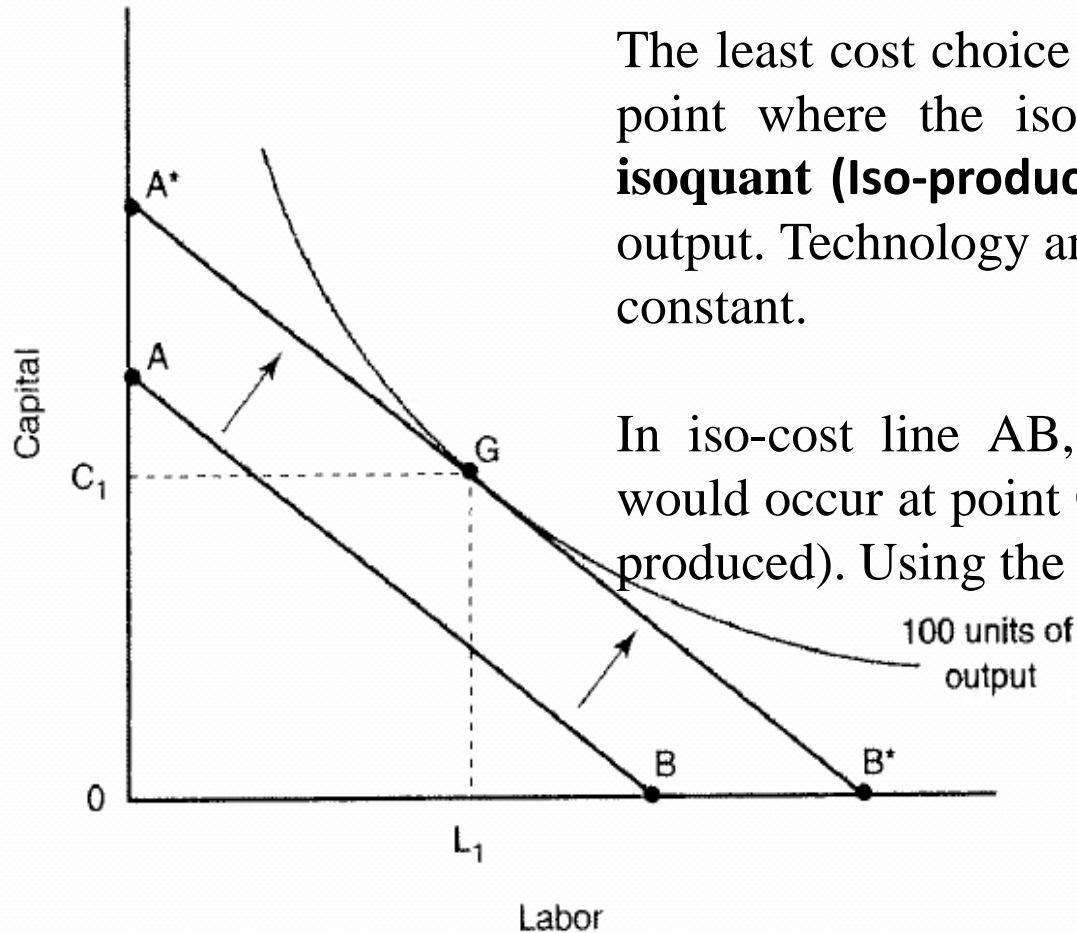


Line MN represents a total cost of production that completely exhausts the amount of money the firm desires to spend.

Firm can afford to produce only 75 units of output using C_3 units of capital and L_3 units of labor

The point of tangency between the iso-cost line and the highest possible isoquant **indicate the least cost combination of inputs associated with the firm's budget constraint.**

Least-Cost Input Choice for Given Output

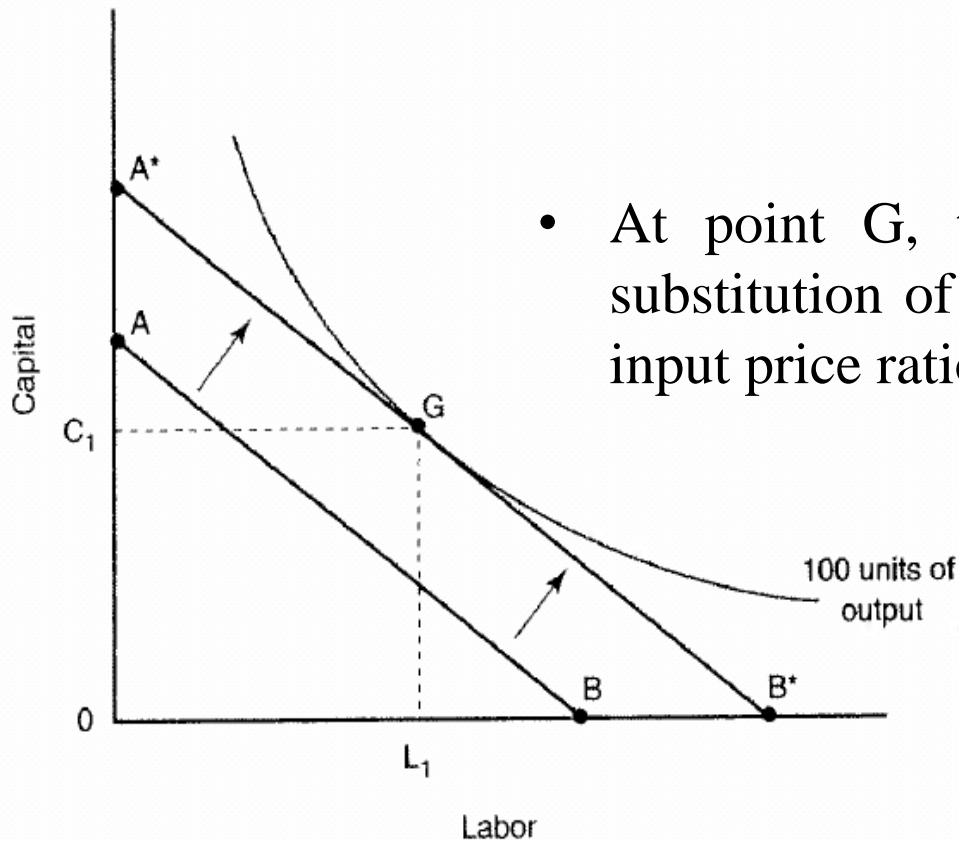


The least cost choice of two input use is given by the point where the iso-cost curve is **tangent to the isoquant (Iso-product curve)** for the desired level of output. Technology and input prices are assumed to be constant.

In iso-cost line AB, the **least-cost combination** is would occur at point G (where 100 units of output are produced). Using the business's productive capacity.

Assume that isoquant AB reflects the existing input prices for labor and capital and current total costs of production.

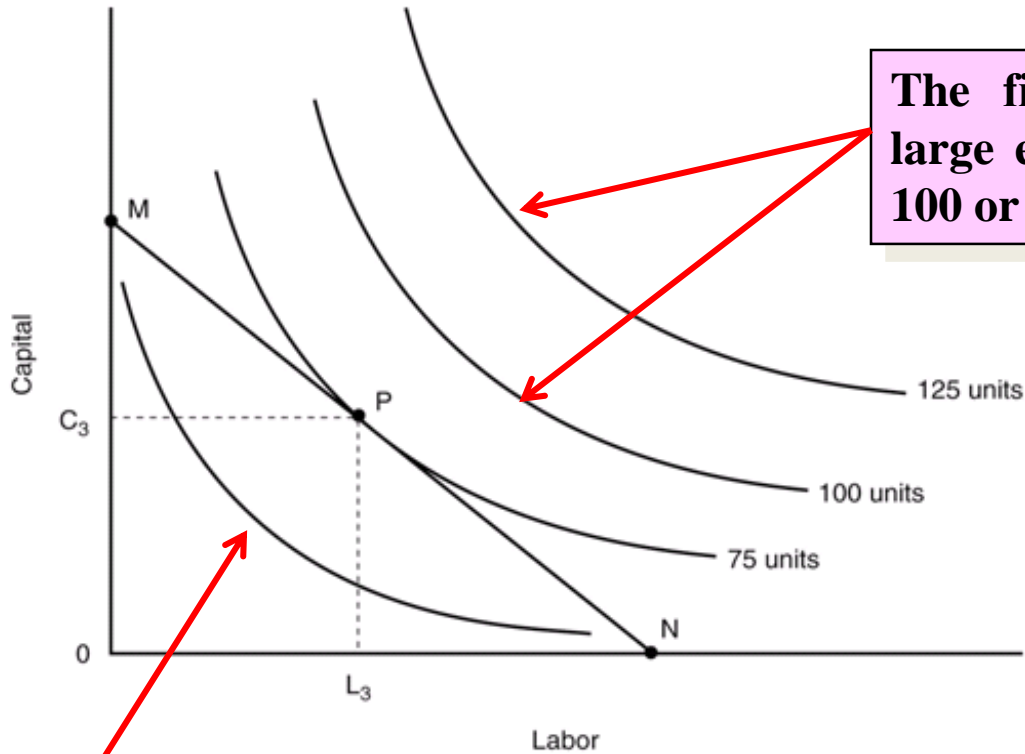
Least-Cost Input Choice for Given Output



- At point G, the marginal rate of technical substitution of capital for labor is equal to the input price ratio.

The least-cost combination of inputs requires that the market rate of exchange of capital for labor (ratio of input prices) equal their rate of exchange in production (their marginal rate of technical substitution).

Least-cost Input Choice for Given Budget



The firm's budget is not large enough to operate at 100 or 125 units...

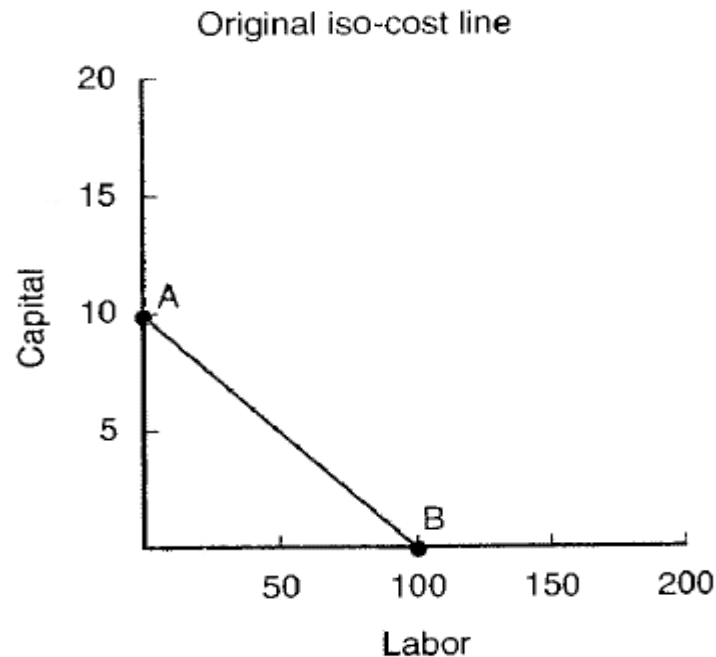
Firm is not spending available budget here...

- A change in one or both of the prices of two inputs cause the iso-cost line to shift in one fashion or another. This will affect the desired use of inputs and even the level of output.

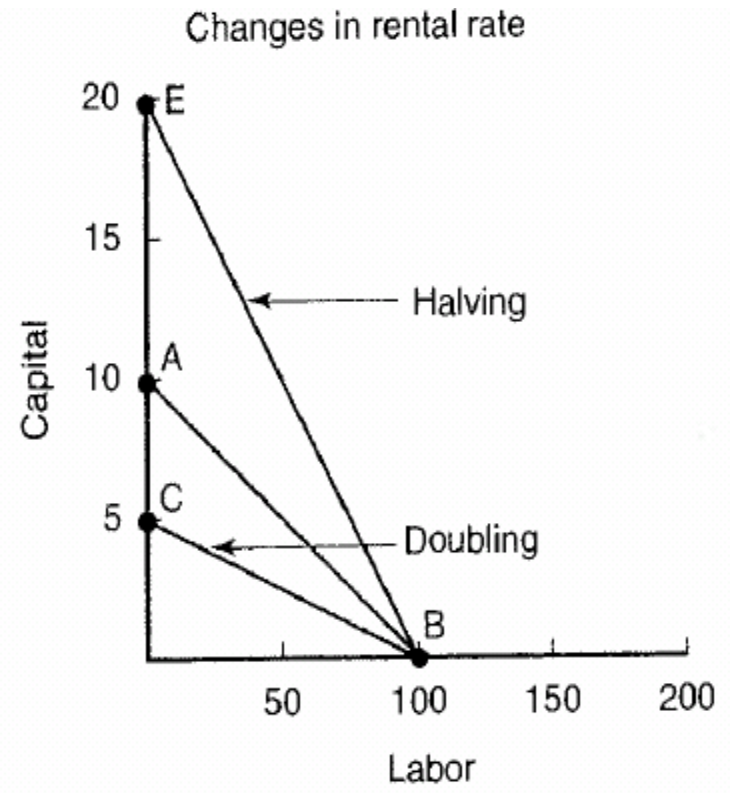
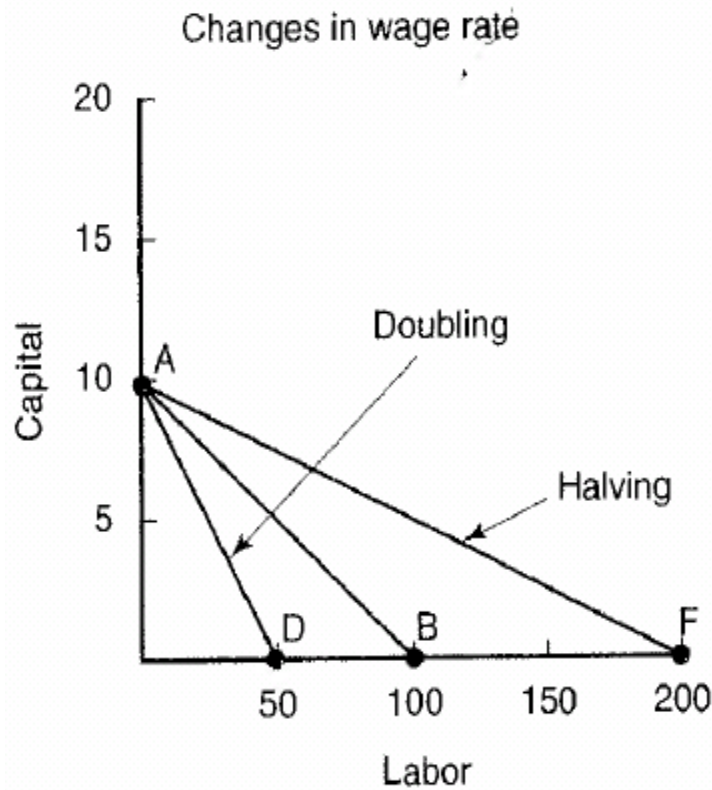
Iso-cost line

- Combination of costs of two variable inputs that a company affords for a given level of total cost is referred to as an **iso-cost line**.

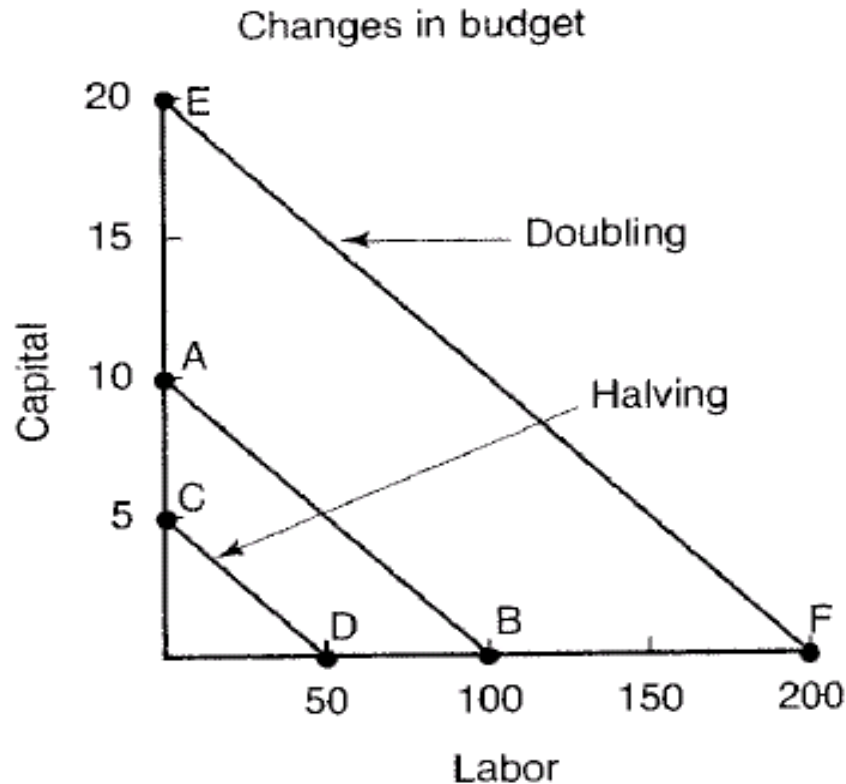
Ex. $\$10 \times \text{use of labor} + \$100 \times \text{use of capital} = \$1,000$



- A change in one or both of the prices of two inputs cause the iso-cost line to shift in one fashion or another.



- An increase in the budget available to purchase two inputs enable the firm to reach a higher isoquant, or produce more output



- **Summary:** *Input use depends on input prices, desired output, and technology. Such cost minimizing input use is often referred to as conditional demand b/s it is conditioned by the desired level of output.*

Question

3.3. Output combinations

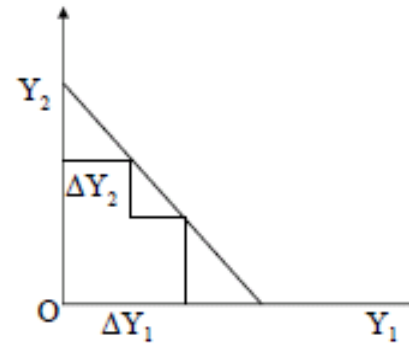
Product-Product Relationship

- Farmers have limited resources and have a number of enterprises/or enterprise combinations of crops and livestock to choose from.
- The question is: How much of what to produce and with what technology. In other words, **what combination of enterprises should be produced?**
 - i) Joint Products: Joint products result from the same production process and the production of one without the other is not possible.
 - ii) Complementary Products: Complementarity between two enterprises exists when with a change in the level of one, the other also changes in the same direction.

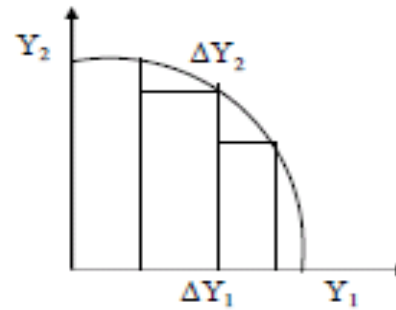
- (iii) Supplementary products: Exists when increase or decrease in one product does not affect the production level of the other product. All supplementary relationships should be taken advantage of by producing both products to the point where the products become competitive.
- (iv) Competitiveness: This relationship holds when increase or decrease in the production of one product affects the production of other commodity inversely.

Competitive enterprises compete for farm resources & substitute for each other. When two products are competitive, some amount of one product must be given up to increase the level of other product. MRPS between products is negative. When two products are competitive, they may substitute at constant rate, increasing rate or decreasing rate.

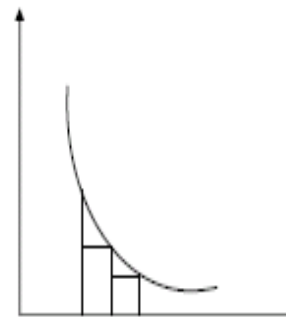
(a) Constant Rate of Substitution



(b) Increasing Rate of Substitution



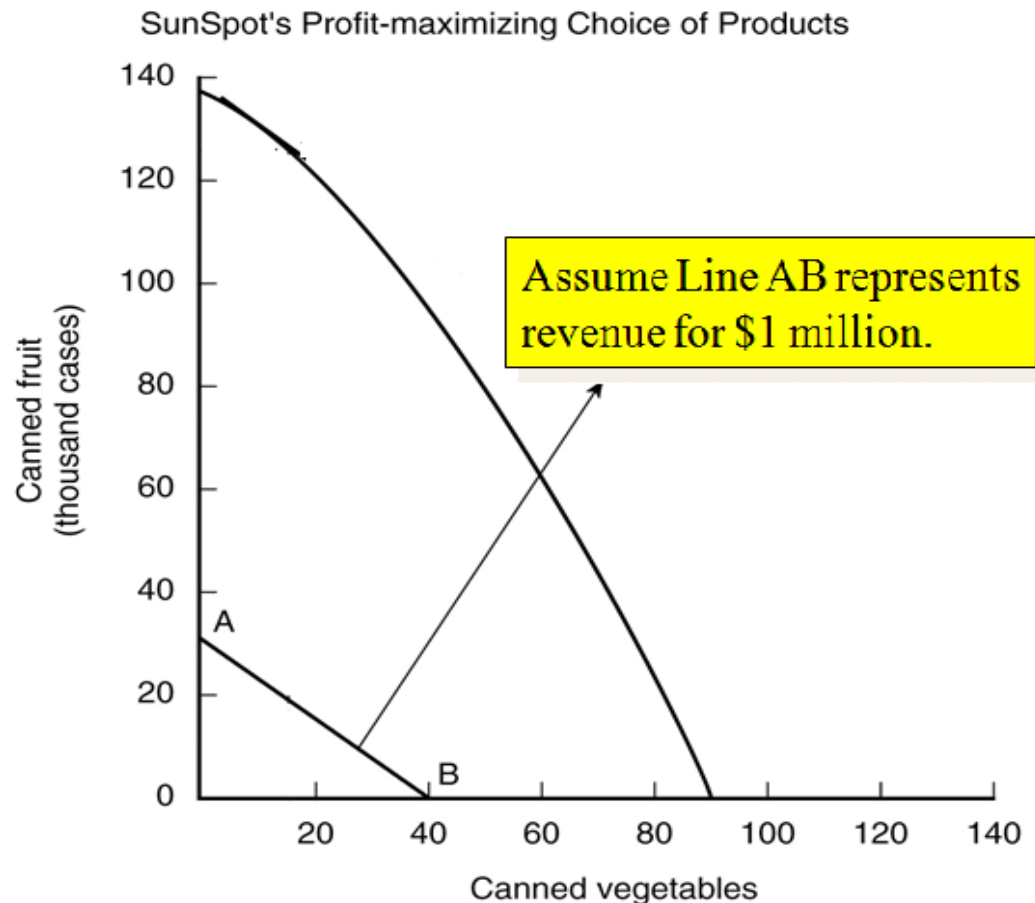
(c) Decreasing Rate of Substitution



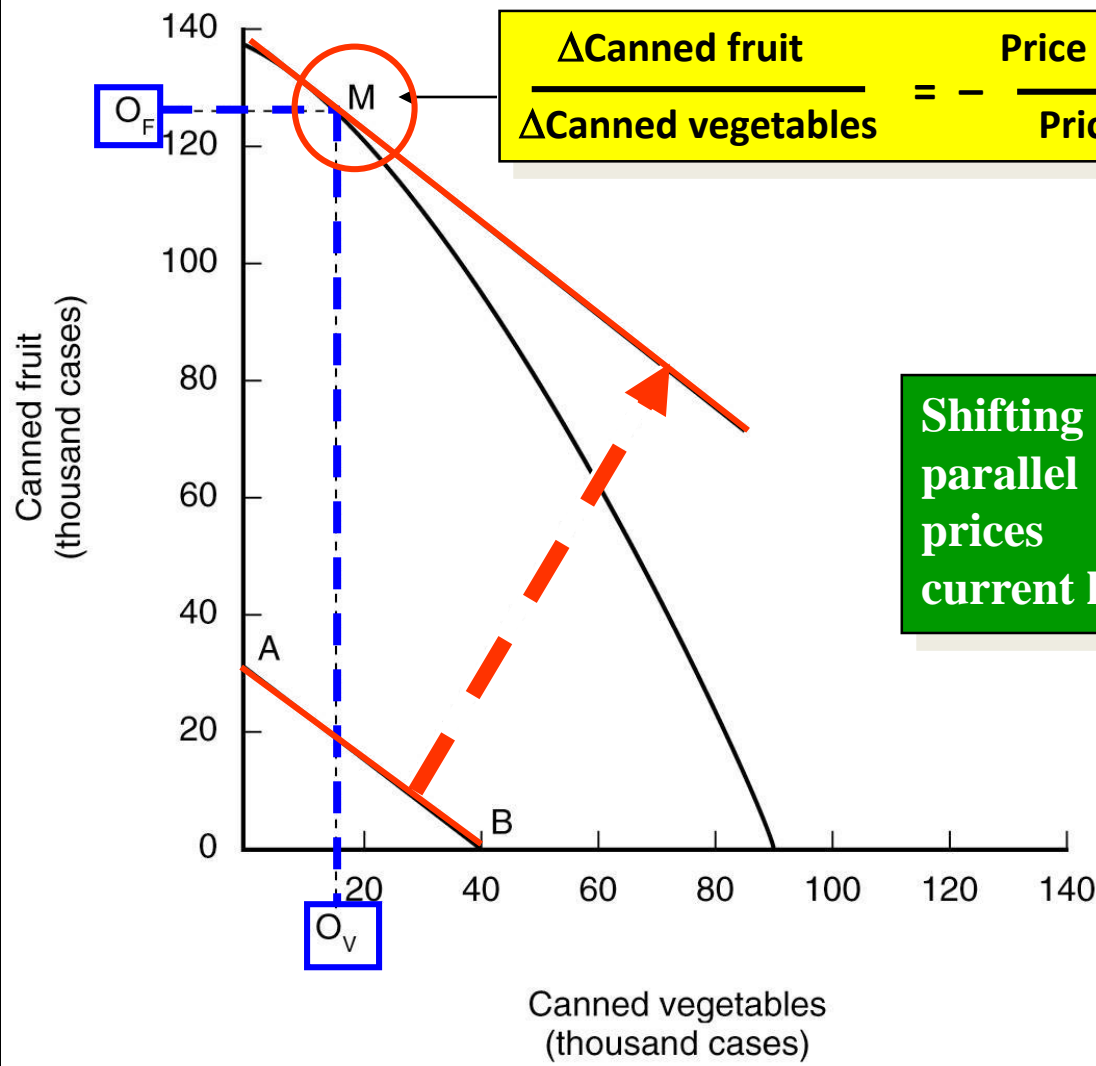
Profit maximizing combination of two products

The profit maximizing combination of two products is found where the slope of the production possibilities frontier (PPF) is equal to the slope of the iso-revenue Curve.

We want to find profit maximizing combination to “can” given current prices of canned fruit and vegetables.



SunSpot's Profit-maximizing Choice of Products



$$\frac{\Delta \text{Canned fruit}}{\Delta \text{Canned vegetables}} = - \frac{\text{Price of vegetables}}{\text{Price of fruit}}$$

Shifting line AB out in a parallel fashion holds both prices constant at their current level

Table 7.2 Production Possibilities for SunSpot Canning

	(1)	(2)	(3)
	Cases of Canned Fruit	Cases of Canned Vegetables	Marginal Rate of Product Transformation, $\Delta(1) \div \Delta(2)$
A	135,000	0	
B	128,000	10,000	-0.7
C	119,000	20,000	-0.9
D	108,000	30,000	-1.1
E	95,000	40,000	-1.3
F	80,000	50,000	-1.5
G	63,000	60,000	-1.7
H	44,000	70,000	-1.9
I	23,000	80,000	-2.1
J	0	90,000	-2.3

125,000 cases of fruit

18,000 cases of vegetables

MRPT equals -0.75

Price ratio = $-(\$25.00 \div \$33.33) = -0.75$

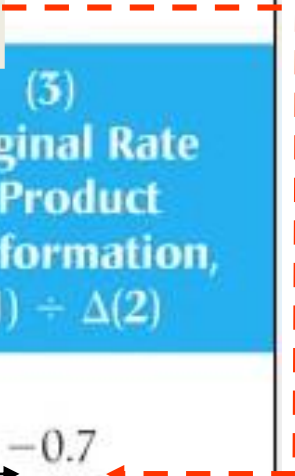
Table 7.2 Pro

	(1)	(2)	(3)
	Cases of Canned Fruit	Cases of Canned Vegetables	Marginal Rate of Product Transformation, $\Delta(1) \div \Delta(2)$
A	135,000	0	
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125,000 cases of fruit

18,000 cases of vegetables

MRPT equals -0.75

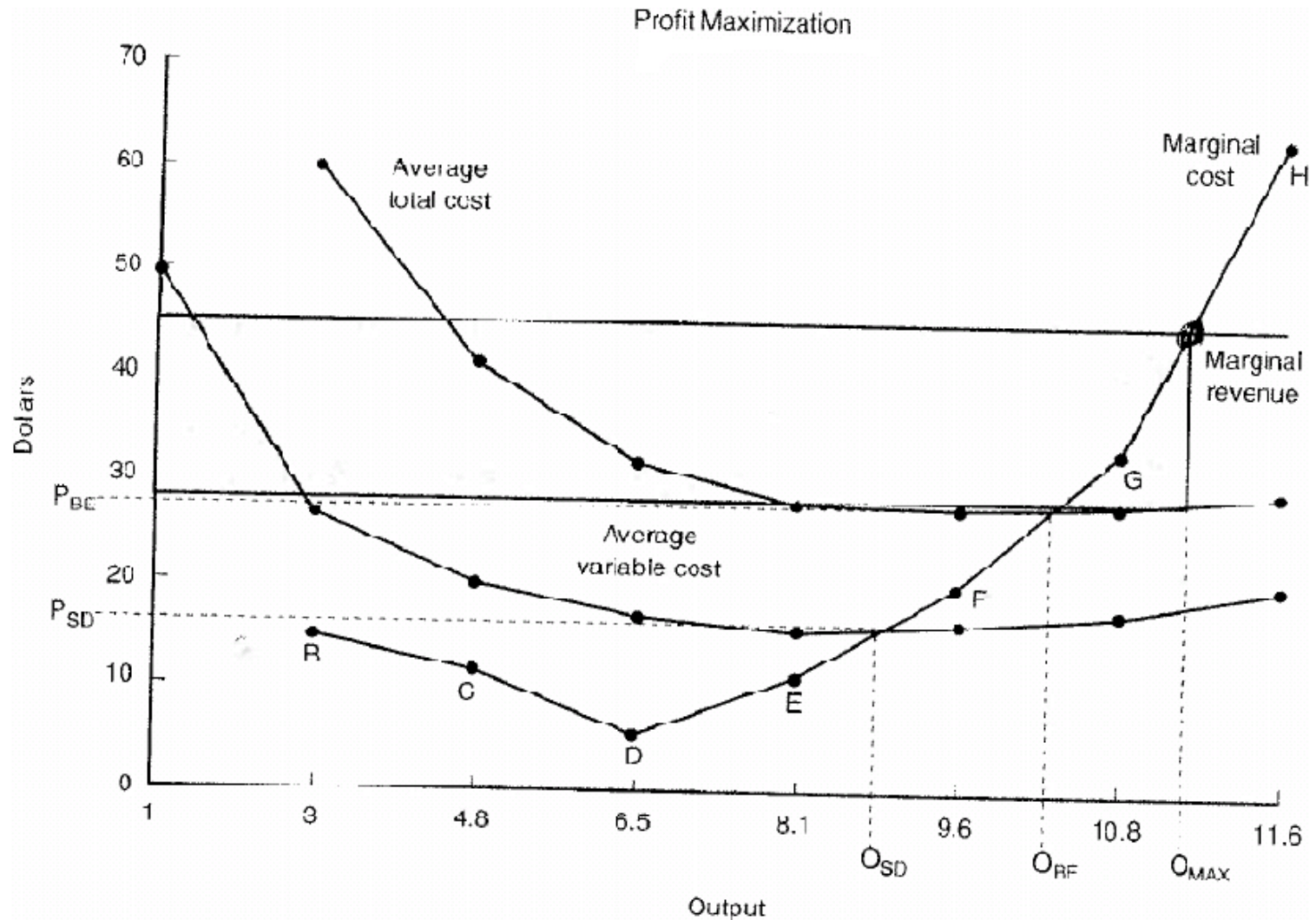


Question

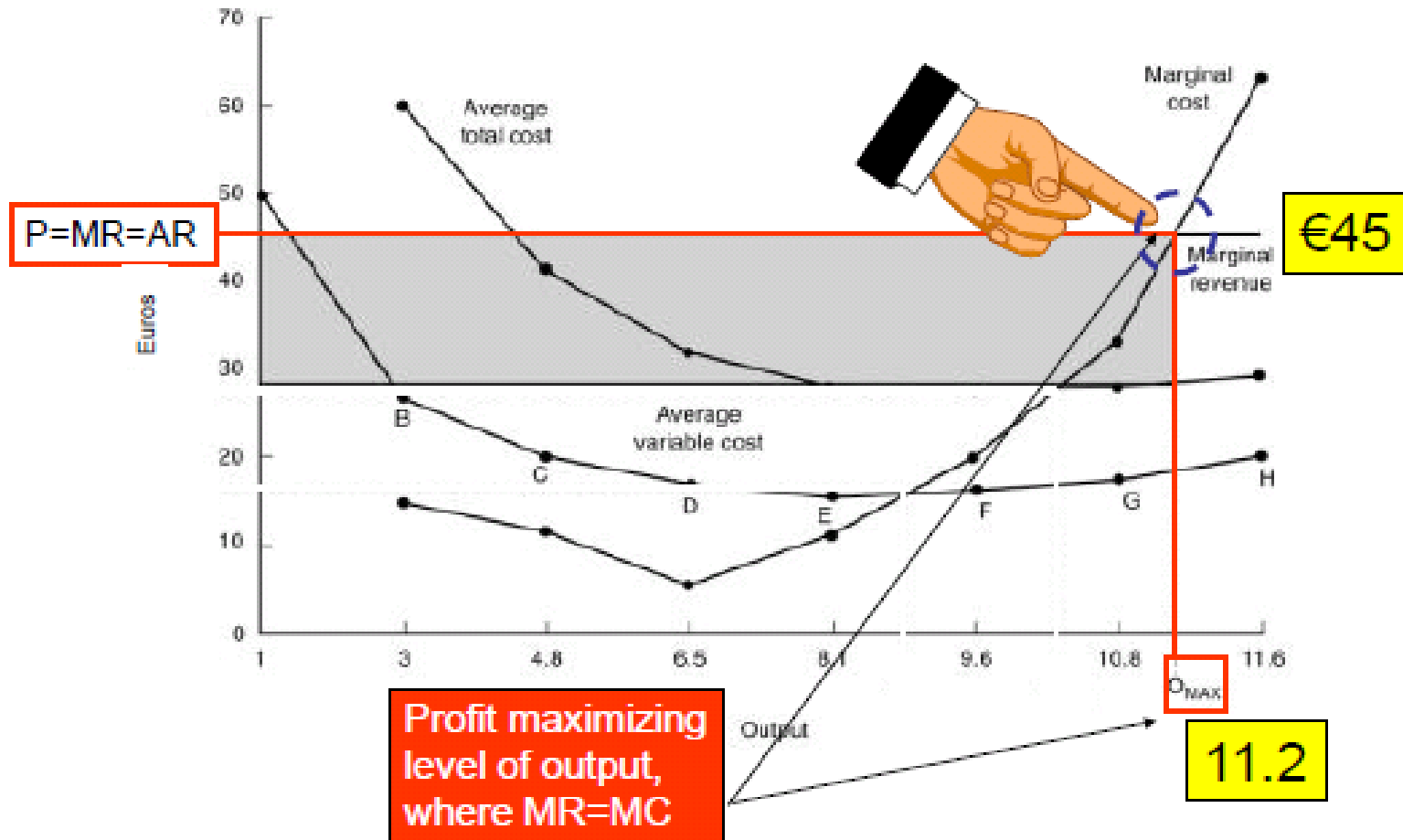
Revenue maximization level of input and output

- It is necessary to determine the **level of output** and **input use that maximize** the business's current economic **profit**.
- The level of output that maximizes profit, or the point at which **MR** associated with the expansion just equals the **MC** associated with the expansion.
- A business **should not increase the use of an input if MC exceeds MR**, or the change in cost of purchasing additional inputs is greater than the revenue the business would receive from their use.

Expansion of the business's variable input use in the current period is **profitable at the margin** as long as the MR exceeds the MC.

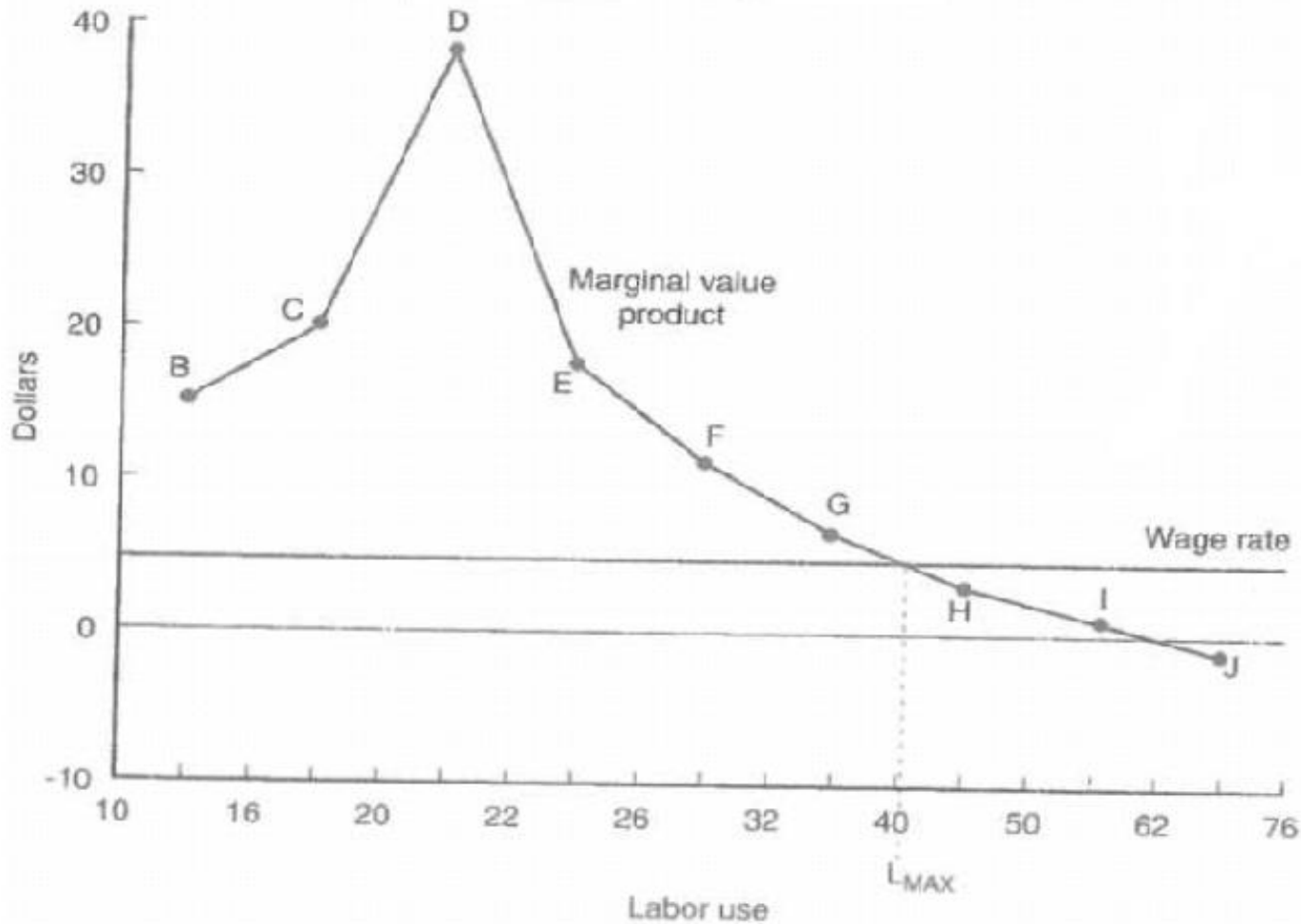


As long as a higher profit is preferred over a smaller profit, a business should not stop expanding production if **MR exceeds MC**. It should produce at the point at which **MR = MC**



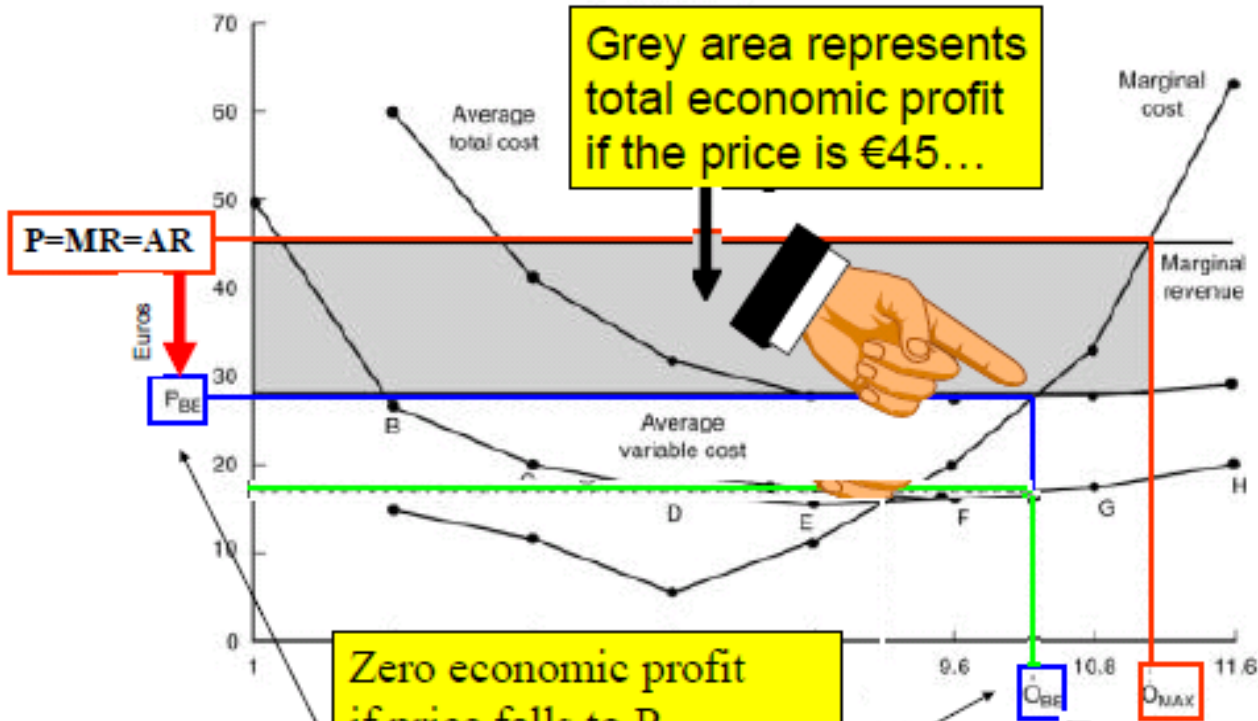
Example

Profit-Maximizing Level of Labor Use



Profit maximizing level requires that the marginal value product (marginal benefit) of each variable input equals **its marginal input cost** simultaneously.

Profit Maximization



Grey area represents total economic profit if the price is €45...

$P=MR=AR$

P_{BE}

Zero economic profit if price falls to P_{BE} . Firm would only produce output O_{BE} . $AR-ATC=0$

Economic losses if price falls to P_{SD} . Firm would shut down below output O_{SD}

Question

4. Economic Impact of livestock diseases

Chapter objectives

- Mechanisms how livestock diseases affect production
- Types of production losses due to disease
- Classifying livestock disease costs

Books used:

- Rushton, J (2009):The Economics of Animal Health and Production. CAB International, UK.
- Putt, S. N. H, Shaw, A. P.NI, Woods, A. J., Tyler, L., and James, A.D. (1987). Veterinary epidemiology and economics in Africa. A manual for use in the design and appraisal of livestock health policy. ILCA manual No.3.
- Martin, W.S. Meek, H.A. and Willeberg, P. (1987). Veterinary epidemiology. Principles and Methods. Iowa state university press, Ames, Iowa, USA
- Thrusfield, M (2005). Veterinary Epidemiology, 3rd ed. Blackwell Sciences Ltd. Oxford.
- Dijkhuizen , A.A. and Morris, R.S. 1997. Animal health economics: principles and applications. Post graduate foundation in veterinary science, university of Sydney, Sydney, Australia.

4.1 How and why are livestock diseases economically important?

4.1.1 Mechanism by which disease affect animal productivity

- Various mechanisms; differ from disease to disease

a. Effect on feeding (decrease intake)

e.g. contagious ectema, FMD, actinobacillosis ...
(affect prehension or movement), any febrile disease (affect appetite)

↓ feeding → ↓ production (productivity?)

- Make distinction between diseases that affect both intake and conversion and those that affect only conversion!
- To what type of production system is it more important?

Cont...

b. Effects on feed digestibility

- Altering morphology or physiology of GIT
 - E.g. ?

c. Effects on physiological process

- nutrient metabolism, respiration and excretion
Particularly protein metabolism

E.g. .

- gastrointestinal parasites cause loss of plasma in to GIT tract
- blood parasites removes hemoglobin

d. Direct feed/nutrient competition

- like in the case of some endo and ecto parasites

Cont...

4.1.2 Effects of disease on economy value of animals

“Disease effect includes increased cost for producer and reduced output for consumers”

a. Premature death:

- market value – value of salvage carcass in case of usable carcass

b. Changed value animals and products from slaughtered animals:

- Lesion and change in body conformation
- Problems that lead to total or partial condemnation of carcass or offal e.g. liver affected by fasciolosis (both for hygiene/health or aesthetic reasons)
- Effect on by-products like sheep skin affected by lice

Cont...

c. Reduced live weight gain

- disease animal gain weight more slowly than their healthy counterparts (less growth, maturation, fertility)

d. Reduced yield and quality of products from live animals

- reduced yield such like milk, meat, wool ,egg and skin and hide
- reduced quality like change milk composition, poor skin quality

Visible quality loss affect producers and invisible ones affect processors or consumers. Explain!

Cont...

f. Reduced capacity to work (draft power)

Draft power represents about 31% of livestock output and valued at 25 billion birr in Ethiopia

- reducing their power (stunting or reduced body condition)
- temporary impairment (like in case of FMD)

g. Reduced dung production for fuel and fertilizer

- Diseases which cause high death rate reduce dung availability

Cont'd ...

4.1.3. effects of disease on herd productivity

a. Reduced productive life of animal

- Disease causing lower production by forced culling
 - chronic disease
 - Permanent loss of production potential

b. Less accurate genetic selection

- disease alters components of productivity.
- reduces efficiency with which animal of superior genetic merit can be identified (if the trait for selection is unrelated to disease resistance)

Answer for the question how are reduced feed intake and conversion affect different production system differently?

Diseases that affect conversion are always bad as they are wasting resources. But those which reduce intake may at least save feed despite low production. This is particularly true in case of hand fed animals in the intensive production system. But for extensive system where animals graze in the field, feed saving is not possible as the feed not utilized will always be wasted.

Cont...

c. Effects on capacity to maintain and improve the herd

- Disease cause fewer progeny not only fewer sell/income but also fewer animals for replacement
- Purchasing replacement has additional risks. What?
- Reproductive tract disease (e.g.) or any systemic conditions that affect fertility (e.g.)

Cont...

4.1.4 Other effects of animal diseases

- effect on cultural value of animal. Some disease make the animals unfit for cultural functions

e.g.

- Animal welfare: suffering of animals

which disease most affect welfare of animals??

: > a rational approach to provision of health care requires that productive and welfare significance rather than the pathological severity of the disease should be the measuring stick for the standard of the service given to the livestock.

4.2. Cost of livestock diseases

Cost = loss + expenditure

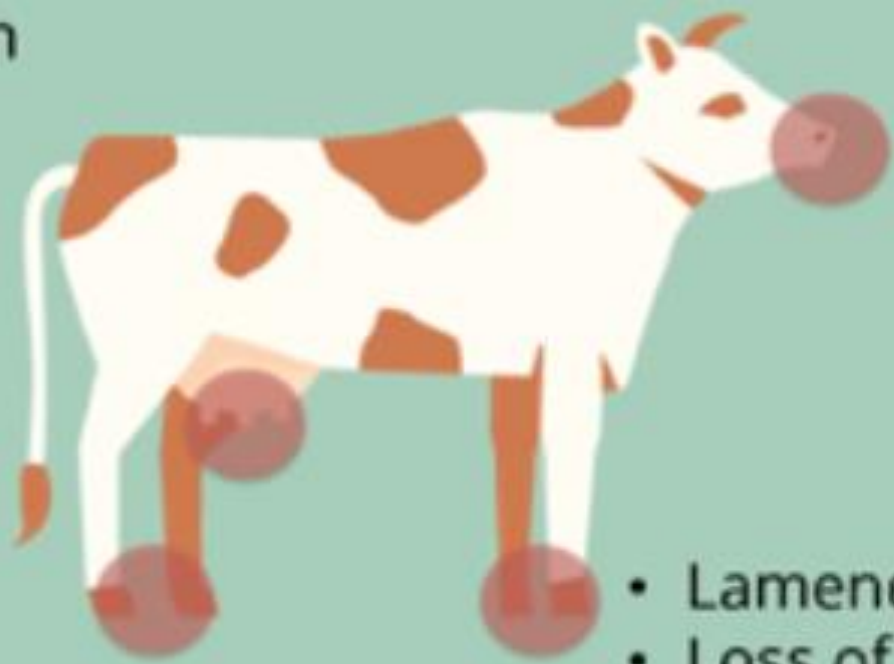
- loss: yield loss, lower price or total discard due to quality, culling ...
- Expenditure: drugs and vaccines, vet fee, addition labor

4.2.1 direct cost (associated with occurrence of a disease)

- Due to mortality, morbidity
- Can be visible(associated with clinical symptoms of the disease visible to the farmers or vets
 - E.g.
- or invisible (associated with long term or chronic impact of the disease that may not be visible for the farmers or vets
 - E.g.

Summary of direct impact of disease an example of FMD

- Death
- Abortion
- Culling



Reduced feed intake
Weight loss
Poor feed conversion

- Lameness
- Loss of draught power

- Reduced milk production
- Mastitis

Impacts of Livestock disease

Direct Impact

Visible losses:

- Loss of milk production
- loss of draft power
- loss of weight gain
- dead animals

Invisible losses:

- fertility problems
- change in herd structure
- delay in sale of animals and/ or animal products

Indirect Impact

Additional costs:

- vaccines
- vaccine delivery
- movement control
- diagnostic tests
- dead animals

Revenues forgone:

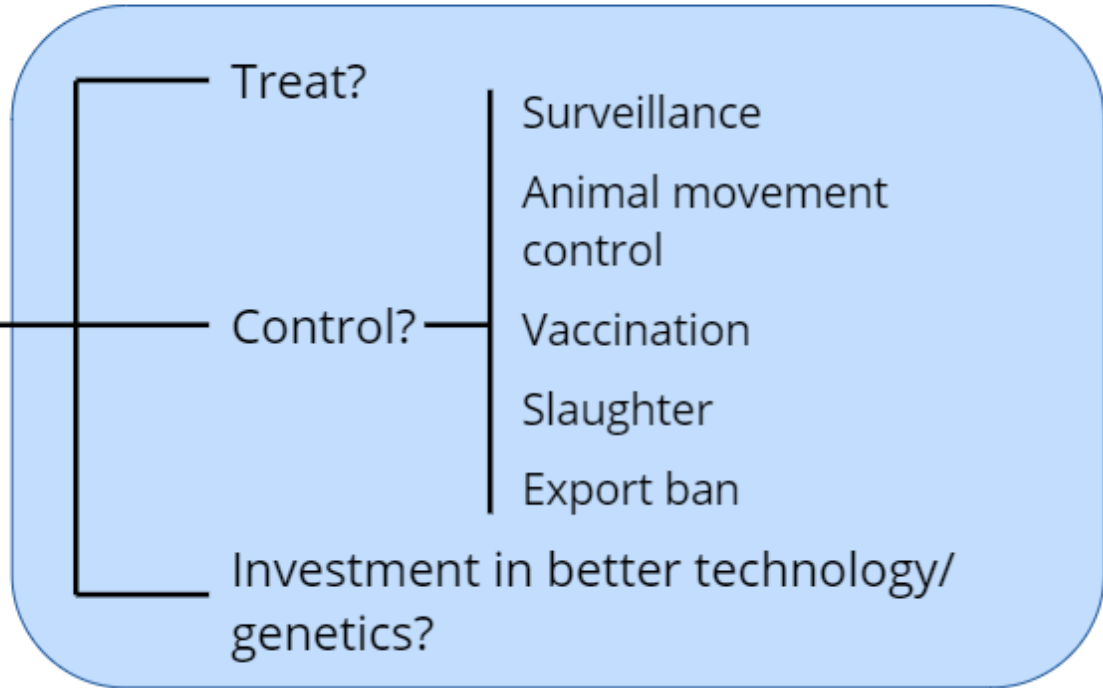
- use of suboptimal breeds
- denied access to markets both local and international

Impacts may be caused by disease, or our reaction to it

Impact caused by the disease:



Impact caused by human reaction to disease presence:



Cont...

4.2.2 Indirect costs (associated human reaction i.e. measures taken to avoid the disease or disease risk = consequential losses)

- Prevent total access to land resource
- Prevent adoption of improved technologies
- Prevent access to lucrative markets (2001, 2006 FMD; 1998, 2003? RFV in Ethiopia)
- Preventive disease control costs like surveillance and vaccination

Note that for the disease to cause indirect cost, the risk should be significant.

Exercise: Provide example applicable to Ethiopia for each case?

Cont...

4.2.3 Other types of disease costs

Zoonosis: In addition to human death & suffering

- Reducing income because of illness, fear of contracting disease and cost of treatment etc.

Secondary effects:

- Losses to other sectors in the livestock chain (ripple effect)
- Losses to other sectors outside the livestock (spillover effect)

Cont...

Externalities:

- costs and benefits that occur during production or consumption activities by one group affect another group without the result being reflected in the market as costs or benefits.
- E.g. a farmer who don't vaccinate his animals may benefit from vaccination by other farmers because of herd immunity.

Exercise: show the relation between externalities and Private/public good distinction of veterinary services

Intangibles:

- effects that exist but are very difficult to quantify in economic terms
E.g. Pain, fears of infection etc.

5. Estimating disease costs

Chapter objectives:

- Quantifying direct costs of diseases as function of
 - value of the animal
 - output reduction from the animal
- Quantify Indirect costs of disease

5.1 Estimation of direct costs

Mortality – relatively straight forward. A bit difficult in chronic diseases (e.g. parasitic diseases). why?

Morbidity – some easy (decrease in yield) others difficult (e.g. reduced fertility)

Treatment and control – mostly easy and direct. It is sum of drug/vaccine, vet fee and additional labour and other logistics

Estimating direct annual losses

Based on the sophistication (detail) of available data direct loss can be calculated either as a function of **value of the animal** or as function of **output reduction**

i. *Losses estimated as function of the value of the animal*

Mortality:

- price reflect a future income from the animal.
- losses are calculated based on *prices* and *mortalities* in each sex and age category

E.g.
$$\sum_{j=1}^6 NMC_{ij} * PC_{ij}$$

Morbidity:

- In the absence of detailed data on the impact of the disease an overall production loss is calculated as percentage of the value of the affected animal e.g. tryps on milk yield or sheep scab on wool

Cont...

- The losses are calculated by taking the following into account for each age and sex category
 - estimated average price
 - Morbidity
 - the percentage loss per animal
 - the number of individuals

Cont...

ii- losses estimated in terms of the effect of disease on the livestock output

Mortality:

- calculated as present value of expected output less costs for the age/sex group or for the average animal

Morbidity:

- Estimated in terms of the effect of disease on the livestock products (meat, milk, egg, wool, young animal and draught power), infertility, abortion, delay in maturity etc
- Needs precise knowledge of reduction in output for which the disease is responsible.
- The calculation takes into account the reduction in each category of output (milk, egg, wool etc)
- In diseases which lead to a loss of weight which may recover by the time the animal is slaughtered **can be quantified** by the cost of delay for slaughter or where there is no delay the cost of extra feed required

e.g. $L_{milki} = N_{cowi} * Q_i * T_{milki} * P_{milk}$

Cont...

Exercise 5.1. (to be reported and scored out of 5%)

What type of data/information would you collect if you want to estimate the cost of LSD outbreak in cattle population of certain district in Ethiopia?

5.2 Estimating indirect cost of disease

- very difficult quantify and often missed
- very often account for a major share
- most effort should be done to quantify and the rest at least should be listed

It can be done based on the difference in income of producers in the absence and presence of the disease.

6. The cost of disease control

Chapter objectives:

- Classify disease control costs based on pattern of expenditure
- Understand the importance of classifying disease control costs

Cont...

Costs of disease control:

- General cost of disease control can be grouped as
 - non medical (preventive measures such as hygiene and quarantine)
 - medicinal measures (drugs, vaccination, pesticides etc.).
- Based on their patterns of expenditure Costs animal disease control are classified as
 - variable and
 - fixed costs

Cont...

Variable costs:

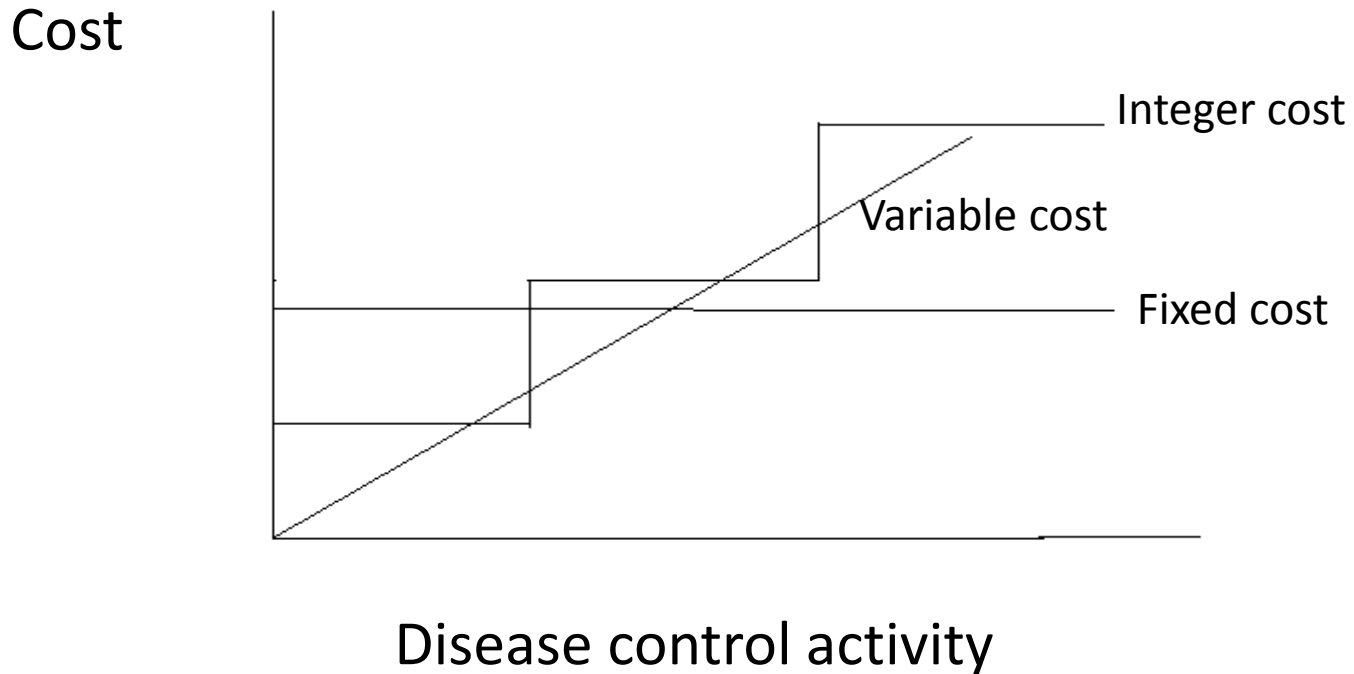
- costs that vary proportional to the number of animals covered in control (seen or treated).
- include diagnostic tests or activities, vaccines, drugs and travel costs etc.
- variable costs are more or less equivalent to the control programs running costs.
- To calculate variable costs it is necessary to work out the costs per animal and to know how many will have to be involved in the control.

Cont...

Fixed costs (overheads):

- Cost that don't vary in short term but vary only in long term
- fixed costs means they once past a certain threshold; there is a sharp cost increase.
- are unaffected by the number of animals dealt with.
- include permanent staff costs plus the costs of investing in capital items required for the control program (e.g. vehicle)
- the actual costs are due to insurance, tax, depreciation
- sometimes there is a third category which is called integer cost. These are costs that vary in medium term.

Identify the type of costs?



Cont...

- The main objective in allocating costs into these categories is to make sure that the elements that contribute to fixed costs are used to maximize capacity.
- Projects frequently waste enormous sum of money because highly paid staff or expensive equipment are not fully utilized.
- Decisions about variable costs can be changed easily but fixed costs are long lasting difficult to change decision once invested

Example of Cost breakdown in disease control program. A case of tsetse eradication in Nigeria (Putt et al., 1987).

year	Reclaim ed land (km ²)	Cost*/k m ² (n)	% of total costs					
			insectici de	labor	junio r staff	senior staff	vehicle running	depreciati on
1973/4	13300	48.3	17.2	42.4	15.5	2.8	3.8	18.3
1974/5	8390	73.2	18.8	41.7	13.8	2.5	3.9	19.3
1975/6	7622	113.0	16.1	44.7	20.9	2.6	2.1	13.6
1976/7	6148	159.2	14.0	48.8	18.4	2.9	2.0	13.9
1977/8	1271	293.8	13.5	25.4	30.0	1.6	6.4	23.1
average			16.7	43.2	17.2	2.5	3.4	17.0

* all cost calculated at a constant (1977/78) prices, the increase is not due to inflation.

Exercise:

- What does the foot note explain? How it is done and Why is it important?
- Compare the share of fixed costs between year 1973 and 1978?

Answer:

- all cost calculated at a constant (1977/78) prices, means all cost are changed to 1977/78 by taking into account the inflation. E.g. the inflation rate in 10% the 100 birr in 1976 will be 110 birr in 1977
- The share of fixed cost higher in 1978 than in 1973 and the efficient (land cleared per unit of money) is less in 1978. this indicates the fixed costs are wasted because of lack operational or variables inputs for the project.

7. Economic analysis of disease control programs

Chapter objectives

- Able to differentiate economics analysis tools used for disease control at farm level and beyond
- Able to differentiate economic analysis that are useful for endemic and epidemic diseases, and zoonotic diseases
- Able to conduct gross margin analysis, partial budgeting, decision tree analysis and cost benefit analysis

cont...

- The objective of economic analysis is to aid decision making regarding limited resource allocation and
- It provides a bases for making rational choices from among alternative measures that uses different combination of resources under various circumstances
- The economic analysis when applied to disease control consists of comparing costs of a program to the effects of (benefits) which it brings.
- Among different techniques of economic analysis used in disease control activities; *gross margin analysis*, *partial farm budgeting*, *payoff table*, *decision tree*, and *benefit cost*. *Cost effectiveness* analysis will be discussed briefly.

7.1 Partial budgeting (PB)

- Budgets are economic (financial) analysis usually done on annual basis
- PB estimates the change that will occur in farm/enterprise profit from some change (animal health related in our case) in the enterprise plan by considering **only those items of returns and costs that change**
- Particularly useful in analyzing relatively small change in the business (e.g. changing from natural breeding to AI or introducing a health herd program)

Cont'd

The general format for partial budget is made up of four sections

- 1. **Additional returns**: a list of returns from the alternative (the new) plan that will not be received from existing base (the old) plan.
- 2. **Reduced costs**: a list of items of costs for the base plan that will be avoided with alternative plan
- 3. **Returns foregone**: a list of items of returns received from the base plan that will not be received from alternative plan
- 4. **Extra costs**: a list of costs of the alternative plan that is not required with the base plan
- Based on the partial budget analysis an alternative plan will be adopted only when the sum of 1 and 2 are greater than the sum of 3 and 4.

Cont'd

- **Exercise:** a sheep farmer has 200 sheep in his flock. Helminthosis is a problem in his flock & causes a mortality of 5% per year. He want to implement a strategic deworming by dosing his sheep two times a year. By doing so the farmer could able to reduce the mortality due to helminthosis from 5 % to 0%. The average price a sheep in the farm is 800 birr. When a sheep died due disease problem the skin can be sold at price of 100 birr per skin. The overall cost of deworming per year per sheep is 20 birr. Conduct economic analysis to determine whether strategic deworming is economically useful to the farm.

Benefits of the new action (strategic deworming)		Costs of the new action (strategic deworming)	
Additional returns	$0.05 * 200 * 800 = 8000$ birr	Returns for gone	$0.05 * 200 * 100 = 1000$ birr
Reduced costs	0	Extra costs	$20 * 200 = 4000$ birr
Total benefits	8000 birr	Total cost	5000
Net benefit	8000 birr - 5000 birr = 3000 birr		

7.2 Payoff table

- GM and PB from animal disease control perspective are primarily used in the assessment of control procedure for endemic disease (helminthosis, bovine mastitis).
- Difficulty arises when consideration is given to sporadic or epidemic disease occurrence which are not certain to occur within the planning period and when there is strong chance element.
- A technique that can be applied to decision making about disease control under such conditions of risk is the payoff table.
- An expected monetary value for alternative strategy is found by multiplying each payoff/returns and costs by its probability and summing these values over all possible outcomes for that strategy

Cont'd

The general format for payoff table

Possible outcomes	Probability of occurrence of the disease	Economic result of alternative strategies	
		1	2
Disease occur	X	a	b
Disease not occur	Y	c	d

Expected monetary value

$$\text{Strategy 1} = (a \times X) + (c \times Y)$$

$$\text{Strategy 2} = (b \times X) + (d \times Y)$$

The strategy with the highest expected monetary value will be adopted

Cont'd ...

Exercise

- In a feedlot that have 1000 animals with average value of individual animal 6000 birr. The probability of the farm to be affected by a disease is 10% . When the disease outbreak occurs, it can kill 3% of animals, if nothing is done to the farm. The farmer has three option doing nothing, prophylactic vaccination, and antibiotic treatment when an outbreak begins. If vaccination, which costs 20 birr/animal, is given the whole herd can be protected. If only antibiotic treatment is given which is 50 birr/ animal when the out break begins, the mortality can be reduced to 1%. Which strategy is the best in terms of expected economic gain?
- NOTE: Regardless of the calculation still the final decision on what strategy to implement rests with the farmer. Because in decision that involve risk, the risk aversion interest of individuals varies.

Possible outcomes	Probability of occurrence of anthrax	Economic benefits from Alternative strategies		
		Doing nothing	Antibiotic treatment	Preventive vaccination
Anthrax outbreak occur	0.1	$(1000*6000)-(0.03*1000*6000)$ = 5 820 000	$(1000*6000)-[(0.01*1000*6000) + (1000*50)]$ = 5 890 000	$(1000*6000) - (20*1000) = 5 980 000$
Anthrax outbreak don't occur	0.9	$1000*6000$ = 6 000 000	$1000*6000$ = 6 000 000	$(1000*6000) - (20*1000)$ = 5 980 000
Expected monetary values		$(0.1*5 820 000) + (0.9 *6 000 000)$ = 5 982 000	$(0.1*5 890 000) + (0.9*6 000 000)$ = 5 989 000	$(0.1 *5 980 000) + (0.9*5 980 000)$ = 5 980 000

7.3 Decision tree analysis

- An alternative to payoff table and used for the same purpose.
- It is a graphic representation of a decision problem
- It is used when there is sequence of decision to be made
- All payoff tables can be presented as a decision tree
- The advantage of decision tree is that they can explicitly depict the chronology of events and can be used to evaluate a sequence of decisions.
- The organization of the chart (decision tree) are depicted as in the next page
 - Decision nodes (squares) are places where alternatives for decision are branched out.
 - Chance nodes (circles) are places where probabilities are branching out
 - End nodes (triangles) are end of the braches

Decision tree

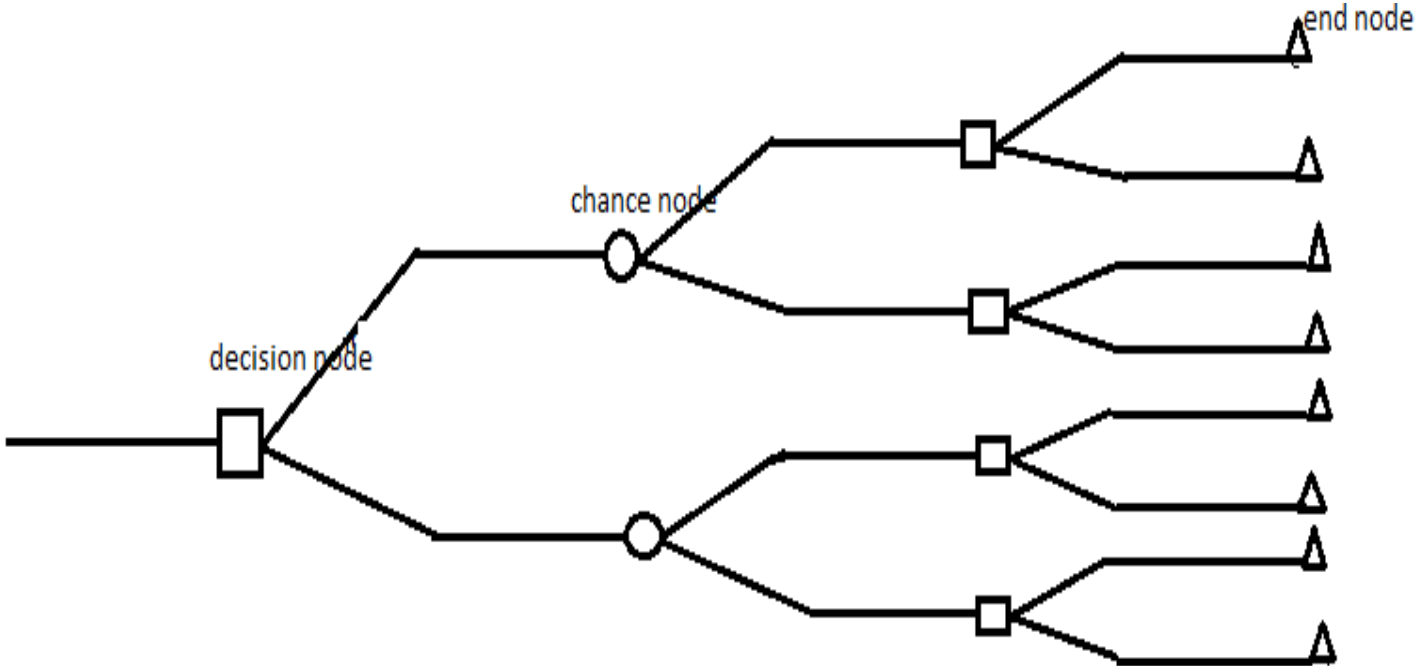


fig . Decision tree organization

Cont'd

Exercise 1.

- Conduct the exercise you did for the pay off table by decision tree

Example: a farmer having a cow with left displaced abomasum has two options: direct abdominal operation or trying rolling for one week and if not successful doing surgery as a final resort. In direct operation the success is 90% while in rolling the success is 60%. The success of operation after rolling treatment is only 60%. The cost of operation is 1000 birr, and if it is done after rolling it costs 1500 birr the cost of rolling for week is 500 birr and the cost of a cow is birr 5000. For which procedure should the farmer go in terms of economic gain.

Exercise 2.

A farmer wants to know what type of tick control strategy to adopt and whether to treat and retain animals with clinical tick borne disease symptoms or to treat and cull. Given the following information conduct decision tree analysis

- Three strategy options: no control, strategic control (\$10/animal) and all-year control(\$30 /animal)
- Disease occurrence probability 40%, 20%, and 10 % for the three strategies respectively
- Cost of treatment per animal is \$25
- A culled animals is valued at \$150 and replacement (normal animal) at \$215 birr
- The loss in production from treated and retained animal is \$35

Hint: Compare the expected costs across the control strategies

7.4 (Social) Cost benefit analysis (CBA)

- It is a technique of economic analysis used in long-term disease control programs at a regional or national level.
- Unlike the previous models, this is used by governments in deciding whether to initiate a large scale animal disease control programs,
 - whether society as a whole will benefit from the action,
 - whether transfer of financial or non financial benefit between sections of the community may result;
 - whether the project should receive priority over other projects and how heavily economic and social achievements of the project should be weighted.
- The basic principle of CBA rests on the premise that a policy should only be adopted when the discounted benefit of the society is greater than the discounted cost.

Some economics concepts relevant for CBA

Compounding and discounting (interest rate/ discount rate)

- **Simple interest (growth)** - is an interest calculated by applying the rate only to the initial sum of money invested i.e. the interest each year is constant unless the initial amount is increased. $FV = PV(1+in)$
- **Compound interest(growth)** - it is an interest calculated by applying the interest rate each year to the initial sum invested plus the total interest earned over the course of the preceding years i.e. the interests increases each year. In practice, the growth (animal population) and interest most commonly are compound rates.

Cont'd

A future value of money from present value can be calculated as a function of the annual interest rate and number of years as follows;

$$FV = PV (1 + i)^n ; \textit{compounding factor } (1 + i)^n$$

Where

- FV = future value in year n
- PV = present value
- i = annual interest rate expressed as decimal not as percentage
- n = number of years
- This process of calculating the future value from present value is called compounding and the exact opposite is called **Discounting**.. The interest rate this time is called discount rate

$$PV = FV / (1 + i)^n ; \textit{discounting factor } 1 / ((1 + i)^n)$$

Cont'd

Inflation and real interest rate

- Inflation is rise in average price level
- Inflation rate = $(B-A/A)*100$ where B is price in the later date and A is price in the earlier date
- Market interest rates that actually paid in the economy include inflation.
- To get profit from putting money to banks, the rate of interest being paid must be higher than the rate of inflation.
- The market rate of interest less the rate of inflation is called **real interest rate**.
- E.g. if the rate of inflation is 15% while the rate of interest is only 12 % per annum, the real rate of interest is negative (-3%).
- Discount rates may need to reflect the real rate of interest.

Cont'd

Opportunity cost and shadow prices

Opportunity cost

- It is the cost of making a particular economic choice, and is given by the cost of alternative production and consumption had to be foregone as result of that choice.

Shadow prices

- The concept of shadow prices is related to opportunity cost. Shadow prices are prices calculated for certain items in order to ensure that their real opportunity cost is taken in to consideration when making decision.
- Using shadow prices in economic analysis will help to appreciate the real cost of using the item for the society and accordingly better decision is made.
- This simply means the prices chosen for analysis should approximate, as far as possible, to the *opportunity cost* of the relevant items to the individual, firm, institution or country from whose point of view the analysis is being made. *See an example in Putt el at, 1987. page 76, table 36.*

Cont'd

Depreciation

It is a loss in a value of a fixed asset as result of wear and tear or obsolescence.

There are two methods of calculating depreciation of a certain fixed asset

i- **Straight line depreciation** = $\frac{\text{purchase price}}{\text{Year of useful functional life}}$

But when the asset has salvage value

$$= \frac{\text{purchase price} - \text{salvage value}}{\text{Years of useful life}}$$

ii. **Diminishing balances** it is used when the depreciation is not assumed uniform over useful life. In this case each year a certain percentage of the book value depreciates

- If the annual percentage depreciation is not known it can be calculated as
$$\text{Annual Percentage depreciation} = 1 - \sqrt[n]{\frac{\text{salvage value}}{\text{purchase value}}}$$

Where n is the useful life

e.g. if purchase value is 100000, salvage value is 10000 and useful life 10 years Then annual percentage depreciation will be 20.57%

Cont'd

Exercise

If a PCR machine is bought for 500 000 birr for a disease control program and it has a salvage value of 50 000 and a useful life of 10 years, what will be the cost using this machine for 5 years? (i.e. what is the depreciation cost?).

1. Using straight-line depreciation method
2. Using diminishing balance method

CBA procedure

- The procedure include the following three elements
 - enumeration of benefits and costs, when they will occur and quantifying them in monetary terms for each strategy
 - determination of appropriate discount rate and calculating the discounted (present value) of benefits and costs for each strategy

$$PVB = \sum_{t=1}^n \frac{Bt}{(1+i)^t} \quad PVC = \sum_{t=1}^n \frac{Ct}{(1+i)^t}$$

B= benefit in each year, C= costs in each year, t = individual year, n= project period in years, i = discount rate

- specification of a decision criterion and choosing the best strategy based on the criteria

Cont'd

The decision criteria

- After calculating the present value of costs and benefits. The next step is making decision of which strategy or program is economically justifiable or that is to say profitable.
- There are three criteria/ measures which have their own advantages and disadvantages that can be used to reach decision. These are
 - the net present value
 - the benefit cost ratio
 - the internal rate of return

Net present value(NPV): it expresses the differences between the total present value of benefits and costs.

- $NPV = PVB - PVC$ or mathematically

$$\sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t}$$

- If NPV is positive the project is profitable
- It indicates the scale of benefits but does not show the relative size of benefits and costs.
- Expensive programs will tend to have high NPV, even if the benefits are only a few percentage points more than costs.

Cont'd

Benefit cost ratio (B/C):

- it is calculated by dividing the total present value of benefit by total value of present cost

- $B/C = \frac{\text{PVB}}{\text{PVC}}$ or mathematically
$$\frac{\sum_{t=1}^n \frac{Bt}{(1+i)^t}}{\sum_{t=1}^n \frac{Ct}{(1+i)^t}}$$

- If the B/C is greater than one the projects is profitable
- It represents the relative size of the costs and benefits.
- It gives no indication, however, of the scale of investment, which should be considered if alternative projects are compared

Cont'd

Internal rate of return (IRR): it reflects the interest rate which would make the total present value of the benefit equal to that of costs, in other words the interest rate which would have to be charged to reduce the net present value to zero.

IRR = discount rate for which $PVB = PVC$, thus $NPV = 0$

IRR = that I for which
$$\sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t} = 0$$

- The project would be considered profitable if the IRR were greater than the discount rate, which in turn should reflect the real rate of interest applying to in the country or relevant sector of the economy (i.e the opportunity of cost of the money!)

Cont'd

Exercise

To control a certain disease, two strategies, A and B, are available. The benefits of a control program are the total expected losses that can be prevented during the time period of (i.e. in this exercise) 5 years. The costs of a control program are the costs made for the program during the same period of time. Future costs and benefits need to be discounted at a rate of 5% to represent present money values. It is assumed that all costs and benefits occur at the end of each year. For each strategy, the benefits and costs are given in the next table. Only the first 5 years are considered, although in practice the benefits of the eradication strategy will continue after year 5. Which strategy would be the economically most favourable?

a. Calculate the discounting factor, PVC, PVB, NPV, B/C, IRR.

Cont'd

Project years	Strategy A		Strategy B	
	Costs (‘000 birr)	Benefits (‘000 birr)	Costs (‘000 birr)	Benefits (‘000 birr)
1	20.00	0.00	1.60	1.00
2	10.00	8.05	1.60	2.40
3	4.00	14.09	4.50	6.50
4	4.00	18.38	4.50	6.50
5	0.00	22.60	6.00	12.30

Financial feasibilities (viability)

- In the economic analysis of projects, in addition to economic profitability, Financial feasibilities should also be considered.
- Financial feasibility deals with availability of funds, and the distribution of benefits and costs (annual cash flow) which are crucial importance for the success projects.
- Actually financial viability is not only about distribution but with outlay also.
- Projects that demand low financial outlay are better than with high outlay.

Project with better financial viability (NPV = 769)

years	cost	benefit	Dis. cost	Dis. benefit
1	6000	1000	5714	952
2	3000	2000	2721	1814
3	2000	3000	1727	2591
4	1000	4000	822	3290
5	1000	5000	783	3917
			11769	12566

Project with poor financial viability (NPV = 769)

years	costs	benefits	dis. costs	dis. benefits
1	12357	0	11768	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	16038	0	12566
			11769	12566

7.5 Cost effectiveness analysis (CEA)

- It is a variant of cost- benefit analysis that is used when the expected benefit are excessively difficult to quantify or the effect is always needed irrespective of its profitability (e.g. the benefits to human population from of rabies control).
- In this type of analysis different strategies are compared with respect to their **discounted costs to achieve the desired outcome (usually a physical outcome)** .
- In the example above the desired outcome may reduction in incidence of rabies and different rabies control projects could be compared with their **discounted cost per unit of decreased incidence of rabies**.

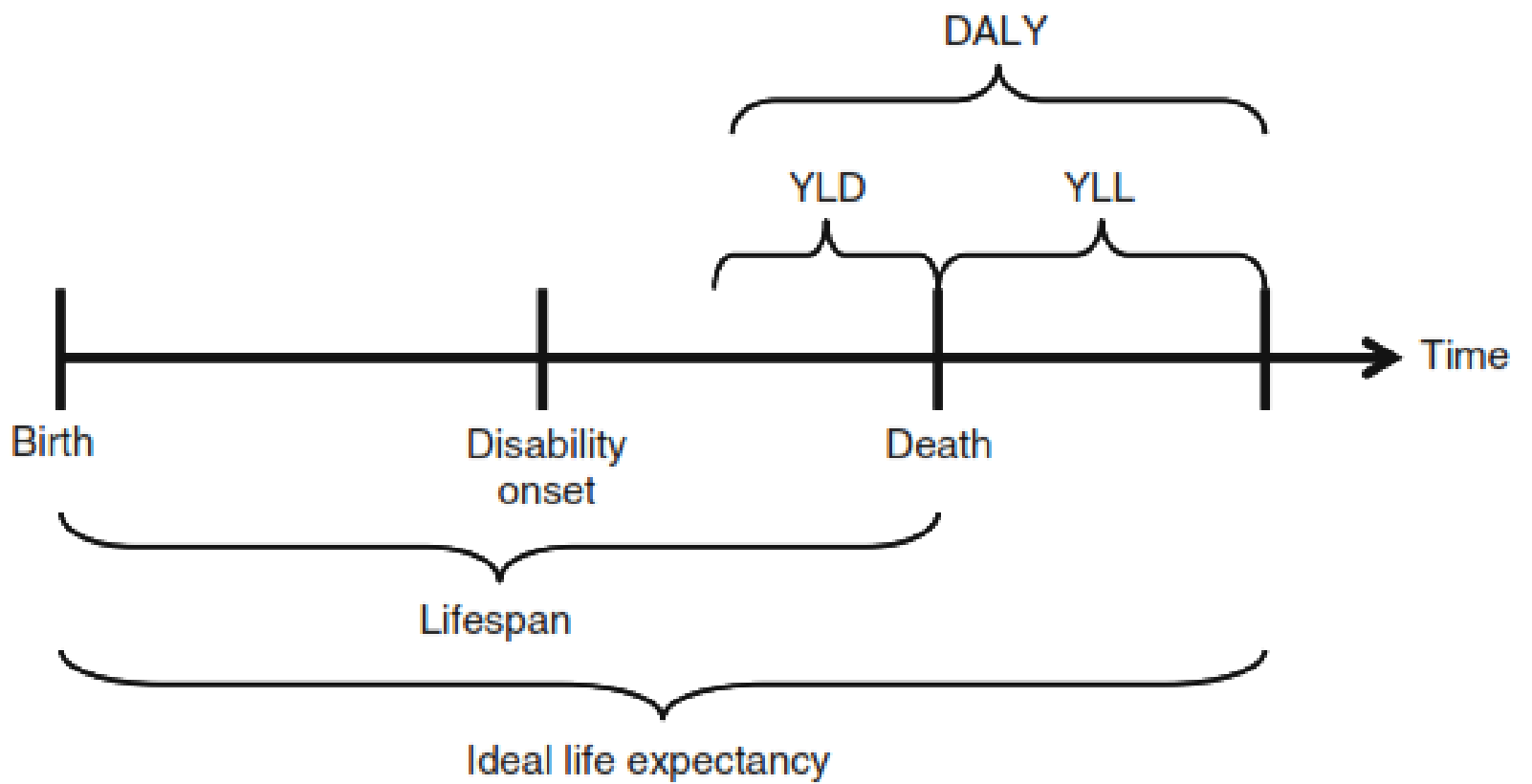
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- So as such CEA is used in medical economics
- A variant of CEA analysis is cost utility analysis where the desired outcome for different effects is combined into single non monetary units.
- In human health the common unit is health adjusted life years (HALY) which can be used as either disability adjusted life years(DALYs) or quality adjusted life years (QALYs)
- In cost utility analysis the benefits then will be compared in terms of DALYs saved or QALYs produced per a unit of money

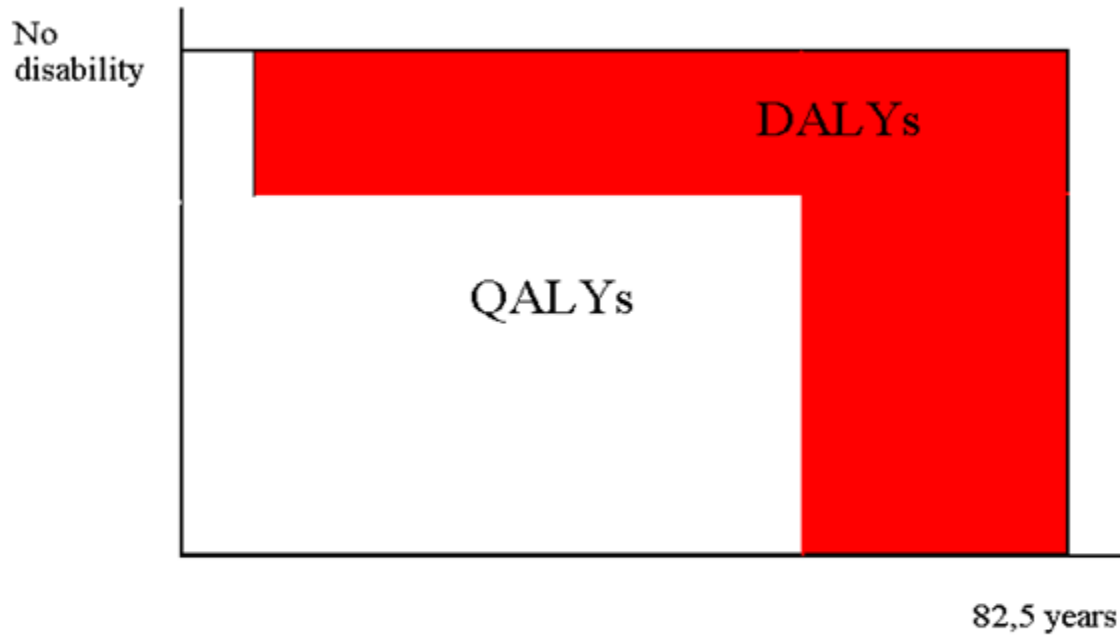
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- One DALY can be thought of as one lost year of "healthy" life
- DALYs for a disease condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality and the Years Lost due to Disability (YLD) for incident cases of the health condition
- DALY is common measurement unit for morbidity and mortality
- Facilitates comparisons of all types of health outcomes
- QALY measure the same thing but form opposite direction i.e. DALY is a negative QALY

Disability weights, which represent the magnitude of health loss associated with specific health outcomes, are used to calculate years lived with disability for these outcomes in a given population. The weights are measured on a scale from 0 to 1, where 0 equals a state of full health and 1 equals death.



Cont'd



Cont'd

- $DALY = YLL + YLD$
- YLL = normal life expectancy at birth– years lived
- YLD = life years with disability x disability weight
- NB: there are issues of age weighting, **social weighting**, and discounting in DALY calculations.
- Exercise: Calculate the DALYs of a woman who has been suffering from diabetes since 40 years old and dies when she is 50: (Disability weight of deafness is set at 0.33 and normal life expectancy at birth is 80 years). Ignore age and social weighting, and discounting future life years

7.6 Uncertainty and sensitivities analysis

- There are numerous uncertainties that make prediction in animal health less accurate.
- Moreover costs and benefits are difficult to precisely determine them over the whole project period.
- All these means the outcome of analysis is affected by a lot factor. These factors should be taken into account during analysis.
- The effect of such uncertainties should be evaluated by a technique called sensitivity analysis.
- Sensitivity analysis is a study of the impact that changes in cost and benefit would have on the profitability of a project.

Cont'd...

- E.g. A 10 % increase in the costs of certain item used in disease control may reduce the internal rate of return of project A from 15 to 10 %. but for project B only from 15% to 13%.
- In this case the first project is sensitive while the latter project is robust.
- Sensitivity analysis is made by using different possible values for relevant items (usually prices, discount rates, benefit estimates, cost estimates etc.) in the economic analysis.
- Looking to the changes in final out come that occur due to change in the value of a certain item, a project economic analysis can be sensitive or robust with that assumption taken for that item.
- At its simplest sensitivity analysis may consists of say looking the effect of a 10% cost overrun or a decrease 20% short fall in expected benefits.

Assignment 1. (10%)

Chose one livestock disease. Write an essay about the economic impact of this disease in not more than one full printed page . In your essay, make sure that you described all the economic impacts of the disease that you chose based on what you have learned in the course. E.g. disease can cause direct economic impact like mortality and morbidity and indirect impact like treatment and prevention cost, trade cost, technology cost etc. some diseases have additional impacts like zoonotic impact.

Assignment 2 (15%)

Search for papers in literature which publishes economic analysis using (1) partial budgeting, (2) decision tree and (3) cost benefit analysis and;

1. for partial budget

- state the objective (s) of the analysis (the paper)
- Appreciate the level of analysis (farm, sector or national level etc.)
- Identify the existing and the new plan
- Identify the additional returns, reduced costs, revenue forgone and extract costs and
- Note whether the new plan is economically profitable

2. For the decision tree

- State the objective(s) of the analysis
- Appreciate the level of analysis (farm, sector or national level etc.)
- Identify the alternative strategies
- Draw the decision tree, appreciate the different nodes of the tree, chances and payoffs
- Note which alternative is economically profitable

3. For cost benefit analysis

- State the objectives of the analysis
- Appreciate the level of analysis (farm, sector or national level etc.)
- Identify which cost items and which benefit items are included in the analysis
- Identify the time horizon of the analysis
- Tell what discounting factor was used
- See which decision criteria was used
- Was the project profitable? If there are alternative projects which was more economical?